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Photo from Underwood & Underwood

Italian Soldiers Hoisting a Powerful Howitzer to a Mountain Top

A GUN THE ITALIANS LOST [See page 339]

The War's Effect On Merchant Shipbuilding—I.*

The Standard Ship and Momentous Problems of Production

By Homer L. Ferguson[1]

In a military sense, this war is narrowed down to the question as to whether the German submarines can sink the English ships and those of the Allies at such a rate as to force peace upon Great Britain, ourselves and the other Allies before the Germans are sufficiently thrashed on land to recognize that fact. When the submarine campaign was started in February, the German Minister of the Navy promised his people that in August of this year England would be brought to her knees. The rate of sinking for a time increased until it became probably three or four times the rate of building.

There have been two schools of thought regarding the proper method of meeting the German submarine campaign. One school has held that only by the production of the maximum number of ships in the shortest space of time until the production of new vessels should more than equal the destruction of vessels in being, would the question be answered. The other school has held that there were vessels in plenty to feed England and to carry our troops to France and to feed them, and that the proper method to meet this menace was to build a large number of submarine chasers, destroyers and other vessels of war to go after the submarine itself. There is a very strong feeling that catching the submarine away from its base is something like catching bees out among the flowers instead of in the hive.

The exponent in an official way of the theory of building the maximum number of ships is, of course, the United States Shipping Board, with the Emergency Fleet Corporation as the largest individual owner and builder of merchant ships anywhere, either at this time or at any other time in the history of the world. All of the shipbuilders have had their new ships commandeered by the Shipping Board, and these ships are now being pushed to completion under the direction of the Shipping Board. In addition to the ships under construction at the time the Shipping Board took over all these vessels on August 3d last, the Shipping Board has placed contracts for 200 to 300 additional steel ships and for about 200 wooden and composite ships. The English have built ships at a very rapid rate during the past six months but prior to that time their capacity had fallen off woefully. The figures of British shipbuilders are that in normal years their capacity in tons was about two million. In 1915 they built only 700,000 tons. In 1916 only 550,000 tons. In the first six months of 1917 they built 500,000 and by the end of 1917 they will have built during this year almost two million tons, or practically their normal tonnage.

In comparison, it is interesting to look at our record, which is mostly in the future. The largest tonnage ever built by us in any year prior to the present year was in 1908, when we built 615,000 tons. In 1917, or at the end of the fiscal year of 1916-17, on July 1st, the total tonnage turned out in merchant ships in this country was close to 800,000 tons. Of course we expect that that will be bettered very much, and the production, except for labor difficulties, would have been very much greater than that; but it is a far cry from 800,000 or 1,000,000 tons of ships a year to a prospective 2,500,000 to 5,000,000 tons of ships a year, and especially when we consider that the best the first shipbuilding country of the world ever did in any one year was only 3,000,000 tons.

Now as to the methods of turning out such an enormous tonnage in a short time. The standardized ship was first thought of by Noah. It certainly would have been had he built a second ark. Every other shipbuilder has thought what a joyful thing it would be if he could only build two or three or four ships just alike. If the war does nothing else for shipbuilding, it will at least demonstrate that the individual tastes of individual owners need not be met in every instance. Ships are not built alike for the reason that ships are built by units and tens instead of by thousands. And what applies to the automobile industry or hat industry or any other industry where the units are small and the aggregate number is very large is not possible where you are building a thing that is worth a half million or a million or more. It is certainly not possible under ordinary circumstances with a very scattered ownership. But with a single ownership, like the Emergency Fleet Corporation, it becomes possible for the owner to specify that all ships shall be alike, and thus we have standard ships!

There is an idea extant that if a ship is called "fabricated" or "standardized" it becomes rather easy to build. It does become easier to build, but it is not any easier to drive a rivet in a fabricated ship than in a common ship, and the 7,500-ton fabricated ship will have about 650,000 rivets and some riveters must do a considerable amount of work to drive those rivets in that ship the same as in any other ship. The most onerous work in building a ship is in the driving of the rivets; and, if any concern is going to build one ship a week, it must drive 650,000 rivets a week. When we consider that the best rivet drive is by the Union Iron Works, where they drive 250,000 rivets a week, and the next best by the three largest shipyards on this coast is about 200,000 rivets each per week, the problem of driving 650,000 rivets a week assumes a rather difficult aspect to the casual observer. Still, we all hope it will be done, but if it is done it means the importation of an enormous number of new workers into the industry.

The fabricated ship has the center of the stage at the present time. In England a standardized ship was adopted which is very much like a fabricated ship, and they are being turned out at a rapid rate. The first ships have already been completed and are on the sea now, if indeed thay have not already arrived in this country. The fabricated ship, like the English standard ship, has the disadvantage of low speed, and at the same time it has the advantage of a large carrying capacity. The records of submarine sinkings, such as have been gathered, indicate that speed is probably the safest defense against the submarine. The number of very slow ships sunk is very great in proportion to the number attacked. Probably 90 per cent of the slow ships are sunk when attacked by a submarine. As the speed becomes greater the immunity of the ship from torpedo attack becomes greater—not only because she presents a more difficult target but also because the vessel may run away from the submarine in darkness or in daylight if she has a greater speed than the submarine has on the surface, and also because the vessel may be maneuvered much more quickly. One of the most gratifying things about submarine warfare is that the torpedoes are not making the speed as in the early days of the war. The speed of the torpedo has undoubtedly become much decreased. Just why we do not know, although it is probably due to the absence of tungsten and manganese and some other ingredients now so difficult to obtain in Germany. Vessels of 16 or 17 knots have actually dodged the torpedoes.

The vessel of 16 or 17 knots is also needed to carry soldiers. We are shipping all our soldiers to Europe in vessels of 14 knots or over because it is thought to be too hazardous to ship them in the slower vessels. We have at the present time in this country enough vessels in commission to ship soldiers to Europe at the rate of not more than one million a year. That includes all vessels of 14 knots or over. But by building a large ship as well as a speedy ship an additional factor of safety is obtained, which may be illustrated by stating that a torpedo will blow just as big a hole in a little ship as a big ship. When a small, short ship has a large hole in it a relatively larger proportion of its length is open to the sea. When a similar hole is blown into a long ship a very much smaller proportion of that vessel is open to the sea. So that it is perfectly possible to design, and practical, indeed to design, a ship of 500 or 600 feet long, so subdivided that it will take two and probably three torpedoes of the German variety and still stay afloat. The design, however, must be of such character that when the compartments are flooded the ship will still remain upright. The requirements of passengers who go to sea are such that the ordinary passenger ship shall have a very small metacentric height. But with a small metacentric height the rolling of the vessel is very easy, so that the passengers are not made ill with the motion of the ship as easily as they would be if there were a large metacentric height and the ship rolled quickly and with a jerk. The ordinary passenger ship is modeled with a small metacentric height, and three-fourths of them, when bilged or torpedoed, will probably turn over before sinking.

A great deal of talk was heard years ago, when the "Titanic" went down, about making ships safe. The "Titanic" was probably the safest ship that ever crossed the ocean, with the exception of the "Olympic." The "Empress of Ireland," the "Lusitania" and the whole host of passenger ships of which we have any record have turned over as they went down, and they probably righted after they went down. So that in designing a ship that will be safe against submarine attack not only must the question of subdivision be taken care of so as to limit the length of the vessel that may be damaged by a torpedo, but also that the vessel when torpedoed will remain upright and be able to get into port. A number of vessels have been torpedoed and have been towed into port and repaired on the other side, even after the crews had deserted them. In fact there is a strong notion that the crews have been over-ready to desert the ships and have left when the ships were still afloat, which is proven by the fact that these ships have been towed in.

The larger type of ship which will probably be built before the war is over by a number of concerns in a position to undertake this work will be designed with a high speed for troop transport, with a close subdivision to make the ship safe, and with a large amount of stability so that the vessel will also be safe against turning over.

The war so far has developed, or called attention to, three distinct types of vessels: The standardized or fabricated ship like both the English and the United States have adopted, the large troop transport which has been described, and, in addition, the submarine chaser.

In addition to these three types of ships brought out by the war, there has been a very definite attempt to rejuvenate what some of us have considered a dead industry. I do not know whether there are many wooden ships building around Philadelphia or not, and I would not like to criticise the wooden ship builders; but I should like to see a few. We have a few of the older wooden ship builders left, but the building of a wooden vessel to my mind is so much more difficult than the building of a steel vessel and requires so much higher skill than does the building of a steel vessel that I wonder how they can ever expect to build them.

I do not believe that a 288-foot wooden ship built in a lumber yard, either south, west or north, and necessarily by men who are not expert ship carpenters, will ever relieve any great distress on the other side of the water, caused by lack of fuel or food. On the other hand, these vessels may be used in our own trade at home. My chief regret is that they are not made shorter, because when such ships are over 200 ft. long it is rather difficult to hold the ends up. If we get more vessels through building wooden ships, let us build them, but it is unfortunate that the type was settled before many professional wooden ship builders were on the job. The wooden ship builders of course have taken a good many men from the steel shipyards and have lessened production to just that extent; but, on the other hand, they will add a very considerable tonnage, now that practically all our large coastwise ships are either going abroad or are in the way of being commandeered for foreign service, so that the wooden ship will serve a useful purpose.

The standard ship probably offers the best opportunity for a large increase in our tonnage. The standard ship has been built on the Great Lakes for years. Shipbuilding there has become largely a manufacturing operation for the reason that the ships themselves simply form a part of the manufacturer's business of carrying iron ore from Lake Superior down through the Canal to the eastern points where it is shipped to the steel furnaces. The loading and unloading of the ore permitted the standardization of docks, hatches and so on, and the method of construction became standardized because the work which the ship did was standardized. Many ask why we do not build ships just like they do on the Lakes, and the answer is that we do not do the same work that they do. On the coast, with the coal trade, there has been some effort toward standardization. With the standardized ship the main benefit is not in the hull of the vessel, or in the fabrication of the vessel in the steel mill. The main benefit is that the machinery and the outfit, the winches, the pumps, the steering gear, the engines and boilers and all the thousand and one things that go into the ship are standardized and may be produced in large quantities at some point other than the yard of the builder. The standardization of the fittings of a vessel are more important to my mind than the standardization of the hull. The amount of money saved in the latter will be the money to build the templets, patterns, etc., amounting to not more than 12½ to 15 per cent of the labor cost of the hull. We are told, too, that all the riveting will be done at the steel mills. It probably will not and if 20 per cent is done it will be more than I think will be done unless the railroads will carry pieces of steel as large as this auditorium.

Shipyards have naturally tried to standardize within their own practice the fittings that go on the various ships

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they build, and a great step is being made in that direction by one of the largest corporations in the country. The Bethlehem Company own so many shipyards that they are in a position to standardize as between their various yards, with the result that there will be considerable saving in cost and in time in the production of all the things that go into a ship. But in building the standardized ship, or in building any other ship, the real problem is not the problem of equipment; it is not the problem of money even; it is not, except in part, the problem of location, but it is the problem of men. A very simple lesson in arithmetic will indicate that if 100,000 rivets are to be driven in one day and any one gang of riveters will drive 300, then it will take so many men and boys and helpers to get that drive. It is quite desirable to get back to our arithmetic again when we have built so many ambitious high hopes of what we expect to do. I can state for our company, the most fortunate thing we did when this war started was that we only promised to deliver ships in the quantity that we had been delivering before. In other words, we did not capitalize our noble purposes and high ambitions, and I am very happy to say that we therefore have only about four more vessels on our hands for which we recieved a fixed price.

Saying that we are going to do a thing does not do it, and *hoping* that we are does not do it, and promising to the newspapers that we are going to build all these ships does not do it. As a matter of fact, enthusiasm and high hopes, unless counterbalanced by good judgment and experience, do more harm than good, because a good many people are lured into a sense of security that we are going to win against this submarine menace, when, as a matter of fact, there is nothing to justify any such conclusion. For instance, on the Delaware and on the Chesapeake, which we, on the Chesapeake, are pleased to consider the two largest shipbuilding communities in the United States, there are at present about 33,000 men employed in the shipyards. There could be employed to advantage in these same yards at this time a total of 48,000 men, and within the next six months, or the next nine months at the latest, these same yards, barring the fabricated shipyards, could employ to advantage a total of 60,000 men. So the problem becomes arithmetical again. You have 32,000 men working. To get the maximum production out of the shipyards already in existence you will need to use 60,000 men. Where are the 28,000 extra trained shipbuilders to come from? Add to that the fabricated shipyards, which on the Delaware will probably require 20,000 men, and in the vicinity of New York an extra 10,000, and we have in this immediate district need for approximately 60,000 new mechanics in the shipbuilding business.

According to Admiral Capps, there will be needed in the whole United States in shipbuilding within the next six months an additional 150,000 men. Now, consider for a minute where these men must come from or how we are to get them. In the first place, most shipbuilding men or mechanics require both skill and experience. We can give them the experience fairly quickly, but we have not time to give them the skill. In other words, it is necessary that men be recruited from industries where they do work similar to the work of shipbuilding in order that they may become quickly adapted to the work of shipbuilding. I say other industries without specifying what particular industry. Of course, it would be natural to pick the non-essential industries if there are any such. But I would say that they should be taken from *any* other industry if necessary, because our problem in the war becomes the most difficult when the question of transportation is considered.

We are operating or preparing to operate 3,000 miles from our base and that is the crux of the whole question. A reasonable solution has been proposed for every physical problem presented by this great war except the problem of over-sea transportation. I do not know whether it is giving away information that would be of benefit to the enemy to say that that transportation is entirely inadequate, but if anyone does not think so all he has to do is to look at the congestion in our various ports. The problem of over-sea transportation absolutely has to be met before we can get into the war effectively, and the problem of sea transportation is probably the most difficult of all problems we have to face. Therefore, the men should be furnished for the solution of this problem, no matter what industry they are taken out of. We are making a fine, large army; we are making all kinds of quartermaster supplies and guns and other things, but none of them are of any use whatever unless carried to Europe. Our soldiers must be carried to Europe, and not only that, but the soldiers that are carried to Europe must be fed and must have ammunition. The excitement created by the war so far will be but a gentle zephyr compared to the excitement that would permeate the United States if, perchance, we get a million men in France from the United States and they go hungry. My own opinion as a plain American is that that is the largest problem that looms up in the future. The distress that has been occasioned here by the sufferings of Frenchmen, Englishmen and Belgians and the different peoples of Europe will be very slight compared with what will be occasioned by some of our boys not having the proper blankets or foods or something else, all of which must be carried to them in ships. So that the problem of building these ships becomes a military problem of prime importance—the most important single problem that confronts us at the present time.

I have been quoted recently in an extract that I gave of this talk to the newspapers as favoring the conscription of laboring men. I do not say that I favor the conscription of laboring men, but I do say this—that sooner or later the United States will tell all men who are essential in any industry or any occupation in the prosecution of the war that *this* is their job and they are to stay by it until the war is over. It is perfectly ridiculous that our men who are already in Europe and those who are going there now should for a minute suffer on account of some difficulties that arise between employers and employees in the great shipyards of this country. Not only should the man who pounds iron and drives rivets be told that he shall be kept on his job, but also every employee in the company, from the president down to the office boy, is to do the same thing, and he is not to seek or obtain other employment, except for good reason given the Government authorities. It simply comes down to this: Whether we are playing a game of amusing ourselves, or whether we are in to win. If we are in the war to win, no one should be timid about telling the laboring man or the unions or anybody representing them just what part they have got to play along with the part that other people should also play. In fact, when the war started a few of us in conversation with the Secretary of the Navy told him that we thought the thing for him to do was to commandeer the shipyards together with all their employees; to put us all on the Government payroll if he wanted to do so, and give us as many stripes on our uniform as he thought proper, and if we did not do as he thought the United States wanted us to do to court-martial us and send us down to Atlanta or some other convenient penitentiary. And I think something of that sort should be done. Any man who has charge of shipbuilding or engineering in any capacity who is not perfectly willing that that should be done both to himself personally as well as to his men has a very one-sided view of this war which needs to be corrected. Of course, it is held by the National Council of Defense, and by a number of exalted bodies that the *status quo* as between employer and employee should remain the same during this war. Of course, it should remain the same, and we all know that it is not remaining the same, and we all know that the labor leaders as a rule are unable to control the men.

There is a solution of this labor problem effected with the transport workers on the other side; Liverpool, for instance. A number of the soldiers were sent back to Liverpool and went to work. You will remember a few years ago in France a great threatened strike on the railroads was settled by making soldiers out of all railroad employees. Our present stevedore troubles are in a fair way of being settled by giving the colored man a chance to be a stevedore instead of being a soldier in the trenches and so far as I have been able to observe in our neighborhood, several thousand of them are glad to take advantage of this glorious opportunity and are stevedoring for their country very quietly and very effectively, and I do not see why of all the men who have been passed into the National Army that we should not have in so essential an industry as shipbuilding those of them who are mechanics on conditions set by the Government and on pay to be approved by the Government, to work in these shipyards until the war is over, or until they should perchance prefer to go to the front instead of staying in the shipyards.

[TO BE CONCLUDED]

A Nomenclature of Smells

A CORRESPONDENT asks, "Is there no genius prepared to give us a nomenclature of smells?" and, referring to a paper on "Wound Treatment" in our columns, suggests that it ought to be possible to name a wound smell, and so to obviate the despatch of samples. An approach has been made many times, but with little success, to the establishment of a system of nomenclature comparable for smells with the classification which we have been able to set up in the cases of the senses of seeing and hearing. The fact is that, so far, smells have not been capable of the analysis which is possible with light and sound. In both these cases we have a gamut or a law of octaves, as also with the atomic weights in chemistry, and perhaps some day a similar analysis in regard to odours will be forthcoming. At present we are without a nomenclature, and everybody experiences the difficulty of describing a smell. We have to be content to say that a given smell resembles another smell which is more or less familiar. The fact is that the sense of smell has been the least cultivated of the senses, and it is just possible that if the subject had received the same attention as have the senses of hearing and sight the study of odors would have reached a higher scientific plane, though, it appears to us, the classification of smells must always suffer from the absence of the mathematical analysis capable in optics and acoustics. As it is, in our struggle to describe a smell we are confined to using such terms as peculiar, persistent, pleasing, disagreeable, sour, bad, musty, sickly, and so forth. Now these are all adjectives which give us little enlightenment. We appreciate at once what is the color of an object called red, and when we fall back on the reference to common objects, for the purpose of more exactly defining a color—thus a yellow color is frequently described as lemon or canary, a red color as brick or claret—our comparisons are made to objects whose hues are fixed by mathematical laws. In the case of sound and light we have a comparatively narrow scale. There are seven primaries as seen in the spectrum and in the range of notes from A to G. It is difficult at present to determine whether smells may be similarly brought into a system of scales or octaves. Such a system, however, has been suggested in the construction of perfumes. Many years ago Dr. Septimus Piesse, for example, set out a series of odors in parallel with a musical scale and showed how it was possible to make a bouquet correspond to a cord. Perfumers thus speak of a gamut of odors, placing the name of the odor in a position corresponding to its effect upon the olfactory sense in the order of the amplitude of vibration. The gamuts of odors thus constructed certainly suggests a law of octaves, for we find that, according to Dr. Piesse's ingenious arrangement, at the lower end of the scale the note B corresponds with clove, while the octave B above gives stocks and pinks and the higher octave B cinnamon. The keen sense of smell will recognize a similarity of odors here just as the musician recognizes the repetition of a note in octaves. The fact that some persons associate certain colors with smells, and that others speak of certain musical notes as suggesting corresponding colors, is interesting sentimentally but not scientifically.—*The Lancet.*

Structure of Hide and Leather Fibres

EACH hide fibre consists of a great number of fibril complexes, each complex containing an undetermined number of fibrils, between which gelatin is found in swollen hide. During swelling and falling, the fibrils and their complexes undergo alterations of position, etc., including twisting, the fibrils of fallen hide however being straight. The interfibrally penetration of alkali during swelling is easily recognized with the ultra-microscopic. Chrome, aldehyde, and chamois leathers show a closer structure of fibres than vegetable-tanned leathers, and are naturally less easily acted upon by boiling with water. While the unswollen hide fibre is more or less optically empty, the leather fibre shows a distinct ultra-microscopic structure, which with vegetable-tanned leather gives information as to the subdivision and amount of tannin taken up, and which can be brought into relation with the physical properties of the leather. The fibrillary structure of gelatin is proved by the ultra-microscope to be a network.—Note in *Jour. Soc. Chem. Ind.* in an article by W. MÖLLER in *Z. angew. Chem.*

A Gun the Italians Lost

SEVERAL interesting photographs have appeared in the pages of the SUPPLEMENT illustrating the sensational engineering feats performed by the Italian army in the prosecution of its campaign on the Austrian border, and on the first page of this issue will be found another view showing a powerful field howitzer being hoisted by derricks and tackle to a snowy mountain top. Hundreds of guns, both big and small, were thus laboriously installed in almost inaccessible mountain fastnesses, but unfortunately, as was developed during the recent calamitous reverses, it was impossible to quickly withdraw the armament thus so advantageoulsy placed. All of these wonderful strongholds among the mountain peaks had to be abandoned when the Italian line was flanked by the Germans, together with their equipment and munitions, and undoubtedly the loss of so many guns is one of the most serious aspects of the catastrophe, for Italy was none too well supplied with guns, and much time will be required to replace them. It was this shortage of guns also that can account for the difficulties encountered in making a quick and successful stand against the advance of the enemy, after the first retreat.

Imitation or Pseudo Coffees

Many Substitutes to Which the War Has Called Attention

THE agreeable and stimulating qualities of coffee as a beverage, which have given it world-wide commercial importance, have led to the exploitation, either openly or fraudulently, of a number of substances known as coffee substitutes. These are not substitutes, properly speaking, but rather imitations or pseudo coffees, since they do not contain all the qualities which give coffee its peculiar individuality.

The moderate use of coffee facilitates both digestion and mental labor, though its abuse may lead to insomnia and nervous tremor. It also accelerates general nutrition and the consumption of the body's reserves. The war has, naturally, drawn increased attention to the products which may be used either to simulate or to adulterate coffee, and a late number of *Larousse Mensuel* (Paris) gives an interesting account of these from which we quote the following passages.

Chicory

Coffee contains three essential principles: *caffeone*, an aromatic principle developed during roasting; a bitter febrifuge; and finally, caffein, which is a stimulant or excitant. It is the presence of this last which forces many nervous persons to forego a drink they are fond of. It is true that in Madagascar and the neighboring islands wild coffee trees are found whose seeds are lacking in caffein (*coffea Humblotiana* and *Perrieri*), but they are marred by an exceeding bitterness, of which thus far no manipulation has been able to rid them, though possibly cultivation may succeed in doing so. Meanwhile since 1908 "decaffeined coffees" have been on sale, which have been deprived by chemical treatment of the stimulating effect of the caffein without losing their aroma.

Hazelnut: *a*, male flowers; *c*, fruit

The pseudo coffees do not possess the properties of coffee and recall its flavor but vaguely. They are either mixed with real coffee or used alone for infusions; they all contain a bitter principle and impart a deep color to water. Reasons of health, economy, or taste have contributed to their use, and some have acquired commercial importance.

Chicory.—"Cafeiform chicory" is mentioned in France for the first time in the *Dictionary of Natural History* published by Valmont de Bomare in 1775. . . . Chicory, *cichorium intybus*, has but one of the properties of coffee, that of giving a deep color to the water in which it is infused; it is acrid, bitter, aperative, depurative and purgative, and slightly nutritious. Some persons use a mixture of coffee and chicory as a matter of taste, especially to prepare *cafe au lait*". Many more use it as a matter of economy. But to this voluntary *clientele* must be added a still more numerous involuntary one,

Lupine: *a*, flower

comprising the habitues of cafés and restaurants and the buyers of ground coffee from unscrupulous merchants.

Nothing is easier than to recognize the presence of chicory in pulverized coffee. One has merely to place a pinch of the suspected powder gently on the surface of a glass of water. Pure coffee will float some little time without coloring the water; chicory on the contrary, being very spongy, rapidly absorbs the liquid, colors it brownish

Chick Pea: *a*, fruit

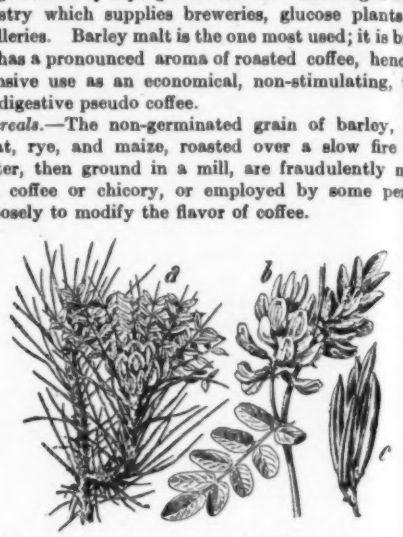
yellow and sinks to the bottom. It is itself often adulterated with cereals, sweet acorns, carrots, the seed-pods of the beet, etc. All these vegetable substances, when dried, roasted, pulverized, and impregnated with caramelized sugar, look like chicory. Sometimes fraudulent dealers even mix it with old coffee grounds, brewery malt, peat, and mineral substances. The "war chicory" which

Carob or honey locust:
a, male flower; *b*, female flower; *c*, fruit

was sold early in 1915 contained all sorts of roasted vegetable tissues except chicory, for the principal regions from which this product comes, Belgium and the north of France, had just been occupied by the enemy.

Malt.—Malt consists of cereals germinated artificially in order to develop a ferment, *amylase*, capable of transforming their starch into sugar, the germination then being checked by drying in heated air. Malting is a large industry which supplies breweries, glucose plants and distilleries. Barley malt is the one most used; it is brown and has a pronounced aroma of roasted coffee, hence its extensive use as an economical, non-stimulating, tonic and digestive pseudo coffee.

Cereals.—The non-germinated grain of barley, oats, wheat, rye, and maize, roasted over a slow fire in a roaster, then ground in a mill, are fraudulently mixed with coffee or chicory, or employed by some persons purposely to modify the flavor of coffee.



Astragal: *a*, of Crete; *b*, glycyphill astragal; *c*, its fruit

Sweet Acorns.—These are supplied by varieties of the evergreen oak, the Spanish oak (*Quercus castellana*), the *Quercus ballota* of Morocco, the *Quercus aesculus*, found throughout the Mediterranean territory; these acorns are edible and are eaten like chestnuts. When roasted and ground there is a considerable trade in them as a pseudo-coffee. The infusion, whose flavor is not very agreeable, is slightly nutritious. They are often replaced by the ordinary acorns of our forests, deprived of their bitter principle by several days' maceration in often changed water and by repeated washing with water containing one to two per cent of carbonate of soda, or sometimes by partial germination procured by placing them in damp earth for a week.

Hazelnuts.—These nuts are shelled and roasted, then enclosed in a piece of cloth and pounded with a mallet while still warm, after which the fragments are reduced to powder in a coffee mill. The infusion from them is a wholesome drink of delicious flavor, but with none of the

Cassia: *a*, fistulous cassia; *b*, flower of fistulous cassia; *c*, fruit; *d*, launceolate cassia

properties of coffee. This product is not to be found in commerce.

Coffee Lupine.—The narrow leaved lupine (*Lupinus angustifolius*), is a leguminous annual with blue flowers, a native of France. It is cultivated in almost all parts of Brittany under the name of "garden coffee," and many of the peasants imagine they have real coffee plants. The seed pod, which ripens in August, contains four or five rather large seeds, almost round, but flattened on both sides; each hill furnishes about ten grammes. After being slowly dried, these seeds are roasted, pounded into fragments and infused in boiling water, yielding a bitter, brown beverage, with a faint aroma slightly recalling that of coffee. The almost universal custom in Brittany of diluting the drink copiously with whiskey completes the illusion. In many taverns lupine is served as coffee in perfectly good faith.

Chick Peas.—The seeds of the chick pea (*Cicer arieti-*

num) valued as a food in the southern parts of Europe, furnish a commercial pseudo-coffee, consumed particularly in Languedoc. The infusion is not specially unpleasant when the roasting has been thorough enough to entirely destroy the taste of the peas.

Spanish Astragal.—This leguminous annual (*Astragalus baticus*), is a herb with yellow flowers. The use of its seeds for a pseudo coffee was quite widespread at the time of the continental blockade; it is still frequent in England.

Carob.—The carob tree, or honey locust (*Ceratonia siliqua*, is a tree of the Mediterranean littoral; its long pods, reduced to a pulp, undergo a roasting process which transforms them into an imitation coffee consumed by the natives of Algeria under the name of *karouba*.

Occidental Cassia.—This shrubby annual legume (*Cassia occidentalis*) grows in the hot regions of two continents. Its seeds, roasted and crushed, furnish the *café nègre* (black coffee) of Senegal, Martinique and Gabon, whose aroma, strongly recalls that of coffee

Goose Grass: *o*, flower, enlarged

though it possesses no stimulating properties. This cafeiform product figured at the Universal Exposition of 1855 among the products of Guadeloupe and it was vainly endeavored to introduce it as superior to chicory. It is used constantly in Guadeloupe, and is sometimes imported into England.

Goose Grass.—This weed (*Galium aparine*) very common throughout France, belongs to the family of madders like the coffee tree. Its fruits, from three to six millimeters in diameter (0.1 to 0.2 inches), are covered with hooked bristles which catch in clothing. They are sometimes used.

Gaertnera vaginata and *Psychotria herbacea.*—These two madders of warm regions yield seeds having a form similar to those of the coffee tree and are used in the same way, but their flavor is quite different and they contain no caffein.

Okra or Gumbo.—The okra, Syrian mallow, or edible ketmia (*Hibiscus esculentus*), is a mallow of warm regions with edible fruit. The seeds are carefully roasted in a

Okra or Gumbo: *a*, fruit

coffee roaster until crepitation ceases; they are then spread on a marble slab or some other article where they will cool rapidly, and crushed. The infusion recalls coffee, with a special flavor which pleases many persons.

Figs.—The use of *feigen kaffee* or "fig coffee" had its birth in Austria Hungary about half a century ago. Thence it spread into Germany and the Balkans. It has been used in France for the last 10 years, especially during the war, and is found in stock in many groceries. The following figures will give an idea of the importance of this product. In 1908 there were imported into Austria (not including Hungary) 2,500,000 quintals of dried figs destined to be roasted, coming mostly from the vicinity of Smyrna. Subsequent to a number of poor crops in Asia Minor the Austrian dealers gave orders to our producers in the South of France and in Algeria. In 1899 a company was formed and a factory erected in Bordeaux for roasting figs. In 1902 the attention of the general government of Algeria was attracted to fig coffee by the large orders for dried figs placed by Austrian dealers. Aided and encouraged by the administration of the colony, industrials went to Austria to study the details of the roasting process, and shortly thereafter two plants were established, one at Bougie, the other at Aomar; they transform into fig coffee a considerable portion of the enormous production of the province of Constantine. The success enjoyed today by fig coffee in France is a result of the war. Many persons have substituted for chicory, because scarce and dear, the roasted figs offered by our producers cut off from their customers in Central Europe. "Fig coffee" resembles ground coffee amazingly; it is sold in tightly closed packets, for it easily absorbs moisture, forming lumps which must be broken. Used alone it yields a sweet infusion of agreeable flavor. Mixed with coffee in the proportion of one third it colors the infusion deeply and modifies its bitterness in place of making it acrid, as does chicory; it sweetens and makes it unctuous and nutritious. The use of fig coffee makes it possible to give children a nutritious *café au lait* whose taste pleases them, yet which contains not a single grain of coffee, a thing not possible with chicory.

It has become a proverb in Austria to say that there is no good coffee without figs. Without sharing this opinion it may be affirmed that the numerous good qualities of fig coffee give it an excellent position in the group of secondary products composed of imitation coffees.

Peat Distillation*

A Low Temperature Process

ALTHOUGH it is generally recognized that the great natural stores of peat in this and other countries are capable of yielding numerous valuable products, the cost of extracting those products from wet or semi-dried peat has over and over again been found to swallow up all the profits of the operation. But the problem continues to engage the attention of inventors, and in the present article an account is given of an apparatus which represents many years of original investigation and has only recently been brought to the stage of practical test. The inventor's aim has been to produce a compact plant which can be erected on the peat bog and which is simple, continuous in action, and economical.

Raw peat, even if well-drained before it is cut, contains up to 90 per cent of water, and parts with its moisture with extreme reluctance. It has been found that, in order the more readily to expel the water, it is necessary to break up the cellular structure of the mass, and that this can best be accomplished by a process of maceration.

REMOVAL OF MOISTURE

After undergoing a simple system of mechanical treatment, and the formation of briquettes, the peat can be dried in a current of hot air, so as to contain as little as 20 to 25 per cent of its weight of water. The drying of the macerated peat takes place in the present plant in a horizontal chamber placed above the retorts. The contents are kept in motion by a scraper or conveyor, by which means the briquettes are turned over and over and travel slowly forward through the hot gases that are on their way to the flue. All parts of the macerated peat are thus exposed in turn to the current of heated air, and at length reach the inlet, placed above the cool end of the retort. The dried peat is fed on automatically through an air-tight valve of special construction. The retorts are set horizontally in pairs and consist of iron tubes some 24 feet in length by 18 inches in diameter. A screw-conveyor passes through the center of the tube, with a clearance of ⅝ inch all round, and is driven at a very slow rate. The charge takes about 45 to 50 minutes to travel through the retort, and as it passes forward towards the firing end the temperature rises gradually till the hot zone is reached.

At the start of the operation heat is supplied by means of producer-gas, generated from a small auxiliary apparatus, working with air-dried peat; but after an hour or so, the gas evolved from the peat undergoing treatment is found to be sufficient for all purposes. This is pumped out of the scrubbers and introduced in the form of jets, impinging against the outer surface of the retort, the air needed to maintain combustion being blown in by a small fan. The jets are arranged in pairs at the hot end of the retorts. As soon as the temperature of the retort approaches 100 deg. C., the peat begins to part with its moisture, and the vapor is drawn off at the upper part of the tube, passing into a condenser of special construction, which takes the form of a series of shallow inverted cones. The hot vapors encounter at the top of the condensers, which are placed on either side of the retorts, a current of cooled gas, acting somewhat on the principle of the injector, and before reaching the scrubber they are deprived of all watery particles, so that only the non-condensable gases are carried forward.

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EXTRACTION OF OILS

At the hot end of the retort, where the internal temperature may vary from 400 deg. to 450 deg. C., the oils given off from the charge are drawn into a separate set of condensers, also placed on either side of the retorts, and the non-condensable vapors are cooled by being passed through scrubbers for use as fuel-gas.

It is important to note that the volatile constituents of the peat are drawn off from different parts of the retort immediately they are formed, and are condensed and separated from the gaseous non-condensable portions in apparatus of a novel and special type, so that the oil contents are withdrawn before they have time to become deteriorated by undue exposure to heat. Moreover, the gas, freed from oil, which results from the carbonization suffices, as soon as a full heat is reached, to carry on the treatment of subsequent charges and thus the distillation process is rendered continuous and self-supporting. It is found that for macerating and briquetting the peat, as also for driving the conveyors, fans, and pumps, in the case of a 10-ton unit, 10 horse-power suffices for all purposes, or, say, 1 horse-power per ton of peat treated.

The yield of oil, which of course varies with the nature of the peat under treatment, amounts to 25 to 30 gallons per ton of dry peat. A definite trial extending over a considerable period gave 26.5 gallons per ton. On distillation of the oil-residues the following results were obtained:

Water	6.00
Oil distilling below 100 deg. C	1.25
Oil distilling from 150 deg. to 250 deg. C	27.40
Oil distilling from 250 deg. to 360 deg. C	48.30
Residual pitch	15.70
Loss	3.50
	100.00

On refractionation of the two fractions 150 deg. to 250 deg., and 250 deg, to 360 deg., fuel oil answering to the Admiralty specification can be produced, and after taking off the oil there is a residue of paraffin wax. In the above run the equivalent of 18 pounds of ammonium sulphate was also obtained per ton of peat.

After extraction of the oily matters and tar, the charcoal, withdrawn from the extreme end of the retort by an automatic process, was found to range from 30 per cent to 33 per cent of the weight of the raw peat. It contained 11.82 per cent of volatile matter, 79.71 per cent of fixed carbon, and 8.47 per cent of ash, though it varies in character in accordance with the density of the peat in the briquette form, and with the length of time the charge remains in the retort. The amount of volatile matter can be raised in accordance with the character of the retort-treatment.

In working up the water solution from this process the yields per ton of peat treated were found to be as follows:

Wood spirit	2.56 gallons
Acetic acid	19.1 lb.
(As calcium acetate)	23.8 lb.
Ammonium sulfate	8.0 lb.

There is also a quantity of tar, varying from 4 to 10 gallons per ton of peat.

LIGNITE, SHALE, AND WOOD

The process is equally applicable to the treatment of lignite, wood, and many kinds of shale, and the costs are, of course lower when no preliminary drying process is required. In the case of a sample of charcoal from lignite the fixed carbon amounted to 67.20 per cent, the volatile matter to 19.60 per cent, and the ash to 13.20 per cent. The process affords a means of utilizing various descriptions of wood refuse, such as shavings chips, or saw dust, and it can also be employed for non-coking coal.

Use of Copper Sulphate in the Destruction of Algæ

IN the treatment of the water in reservoirs with copper sulphate to destroy algal growths and keep the water free from weeds, 1 part of copper sulphate per 3 million parts of water is sufficient, and this amount has no injurious effect on fishes. The number of bacteria present increases shortly after the addition of the copper sulphate, and then decreases, the increase appearing to be due to the decomposition of the algæ. The best way of adding the copper sulphate is to place the salt in a perforated copper tank fixed at the stern of a punt, so that the crystals fall through the holes as the punt passes through the water.—G. EMBREY in *The Analyst*.

The Ethnology of Scotland*

By A. Keith

It is as a fighting man that the Scot makes his first appearance in written history; Tacitus depicts him as ruddy in color, big in body, strong in limb, and Germanic in origin. In 1866, when Huxley[1] described the human remains discovered by Mr. Samuel Laing in a long-cist cemetery at Keiss, Caithness, which the discoverer regarded as of early Neolithic date, but which are now rightly assigned to a much later period—an early phase of the Iron age—he had clearly reached a conclusion very similar to that of Tacitus:

"But the existence of a tall, long-headed, fair element becomes intelligible at once if we suppose that long before the well-known Norse and Danish invasions a stream of Scandinavians had set in to Scotland and Ireland and formed a part of our primitive population (p. 134).

Huxley regarded the Scottish people, the Irish, the Norwegians, and the Swedes as possessing a common basal stock or type. Prof. Bryce, of the University of Glasgow, who has done so much to build up an accurate knowledge of the early inhabitants of the south-west of Scotland, accepts Huxley's hypothesis, and supposes that in early Neolithic times—before the long-barrow people, of Mediterranean origin, had reached Arran—Ireland, Scotland, and Scandinavia were already peopled by the same tall, fair, dolichocephalic stock.[2] Dr. W. C. Mackenzie[3] has also come to a somewhat similar conclusion from a study of the place-names of Scotland and Ireland, but supposes that the arrival of the Scandinavian or Germanic people occurred at a post-Neolithic date. The same hypothesis has also been sturdily advocated by Mr. John Munro.[4]

Huxley preferred the term "Scandinavian" to "Germanic" when he wished to designate the tall, big-boned, fair, long-headed Scotsman, because he was well aware that this type prevails only in the western fourth of the modern German Empire. "Celt" and "Celtic," "Teuton" and "Teutonic," "German" and "Germanic," are terms which the modern anthropologist has had to abandon; all have been applied to the type of man Tacitus and Huxley had in mind, and also to physical types which are totally different. To the tall, long-headed Xanthochroi most modern anthropologists would apply the term "Nordic" in preference to "Scandinavian."

When we seek for evidence as to the time and manner in which the Nordic type reached Scotland we naturally turn to the three Scottish universities which have become centers of anthropological investigation—Edinburgh, Glasgow and Aberdeen. We shall take the last-named university first, because the school of anthropologists which has grown up under Prof. R. W. Reid, Dr. Alexander Low, Mr. James F. Tocher, the late Dr. W. R. Macdonell, and the late Mr. John Gray can show us very precise and remarkable facts bearing on the early history of the people of the north-east of Scotland.[5] All over the county of Aberdeen are found burials in short stone-cists, which certainly date back to an early stage of the Bronze age, and have been given an approximate date of 1500 B. C. by the Hon. John Abercromby. There could not be a sharper contrast between two human types than there is between the Nordic and those squat, bullet-headed, short-cist people of Aberdeenshire. The latter were a wonderfully uniform folk, showing a peculiar type of brachycephaly. To find the nearest approach to that type in a modern population we have to go more than a thousand miles away, to the countries lying at the upper waters of the Elbe and Rhine. In the ancient graves of these same areas of central and south-west Germany the Hon. John Abercromby finds the prototype of the "beakers" which were so often placed in the Aberdeenshire short cists with the dead. Between 3000 and 4000 years ago Aberdeenshire was invaded by a brachycephalic, Slav-like people. We have ample evidence to show that the round-heads of Central Europe broke through the Nordic barrier that still guards the eastern shores of the North Sea about the end of the Neolithic period, some 4,000 years ago. Nor need we hesitate to believe that they had the means to cross the North Sea. In that great work,[6] whereby a foundation for a real history of the Scottish people was laid, Sir Daniel Wilson describes the discovery of a boat at a depth of 15 feet in the carse of Falkirk. The boat was 36 feet long and 4 feet wide. We know approximately when the silt of the carse was deposited and the boat embedded; it was when the 25-foot beach marked the level of the sea and when the hunters of Scotland used that peculiar form of harpoon which marks the transition from the Palæolithic to the Neolithic civilization. There were apparently big boats in Scotland several thousand years before the Continental or German round-heads landed on the shores of Aberdeenshire.

Unfortunately the anthropologists of Aberdeen University can show us nothing of the people who preceded the round-heads or of the people who followed them. But they have provided us with the means of ascertaining how far the stock introduced by the short-cist people has been perpetuated.[7] In 402 men examined by Mr. John Gray and Mr. James Tocher there were only 5 per cent who had the peculiar head form and dimensions of the short-cist people; there were 9 per cent who were technically of the round-headed type with a cephalic index of 80 or more. The prevailing forms varied between the upper limits of long-headedness and the lower of round-headedness. These modern Buchan people were, on an average, about four inches taller than the short-cist men and had the fair coloring in hair and eyes of the modern Bavarian. How and when the Nordic type reached Aberdeenshire we have no precise evidence. But it certainly is at present the prevailing type.

We come now to deal with the contributions which the late Sir William Turner, principal of the University of Edinburg, made to Scottish ethnology. He may be described as one of the best Scotsmen ever born south of the Tweed. When he arrived in Edinburgh in 1854, at the age of 24, to assist Goodsir, he found Daniel Wilson, who had opened so brilliantly the first chapter of Scotland's ancient history, on the point of departure for the University of Toronto, of which, in the course of time, he became the distinguished principal. Another young Englishman, the late Dr. John Beddoe, had just finished his first preliminary survey of the Scots: he found them to be a compound of Saxon, Pict (Iberian), Celtic (a hybrid between the British of the Neolithic and Bronze ages), and Welsh. Turner had a predilection for facts rather than theories, and he began to collect, in a systematic manner, the materials for a craniological history. His numerous pupils became willing assistant collectors, and in the course of fifty years he assembled in his museum the most extensive collection of ancient and modern Scottish crania that has as yet been made. When he retired from the chair of anatomy, to assume the onerous duties of principal of the University of Edinburgh, he devoted his spare hours to the study of his carnial collections. He published two monographs[8] on the Scottish crania, the first, issued in 1903, being a detailed description of 176 skulls of modern people; the second issued in 1915—a few months before his death at the age of 84—in which he gave an account of prehistoric crania and stated his conclusions regarding the races which had become fused to form the Scottish nation. He had, including the Aberdeenshire series already mentioned, 49 skulls from short stone-cists, representing Scotsmen of the Bronze age. Of the 49, 38 were discovered in the eastern counties; of these, 34 were brachycephalic, of a type very similar to the Aberdeenshire series, yet showing a sufficient degree of difference to lead one to suspect that there was at least a tribal distinction.

Turner agreed that the people buried in the short stone-cists were Alpine or Central European in origin and represented the Bronze-age invaders of Scotland. Of the more ancient Scots, those who buried their dead in chambered cairns in the latter part of the Neolithic period, he had only ten examples, five of these being borrowed from Prof. Bryce's Arran series. These chambered-cairn men are as different from the short-cist men in head form as men can be; the people from the chambered cairns have the same cranial shape and dimensions as the people of the long barrows of England. Turner accepted the opinion that both were of the same race and that they were traceable to a Mediterranean stock. One cannot help being impressed by the length and relative narrowness of the face of the more ancient Scottish skulls; we seem to see in them already the peculiar traits so common in the faces of modern Scots.

Sir William Turner had at his disposal two crania which may possibly belong to an earlier date than the skulls from the chambered cairns. They were found by the late Dr. Joseph Anderson, when he discovered and opened the MacArthur cave at Oban in 1895. We know that the MacArthur cave was inhabited at the very earliest phase of the Neolithic period, but as one of the skulls was on the floor of the cave and the other—a very remarkable skull—was only embedded in the upper shelly stratum, we cannot be certain that they represent the ancient inhabitants of the cave. They are both of the Neolithic Scottish type. The more deeply embedded cave skull has a remarkable resemblance to that of Robert Burns; as seen in profile they are almost identical. The cave skull has the remarkable length of 205 mm., that of Burns 206 mm.; they are almost identical in height of vault, but there is a decided difference in width—that of the cave skull being 138 mm., while Burns's cranium had a width of 155 mm. The poet had an enormously capacious skull. The essential differences between the few Neolithic Scots we know of and their modern successors lie in an increased stature and an increased width of head in the latter.

Of the people who lived in Scotland in the early Iron age, the people who succeeded the short-cist round-heads, Sir William Turner had to own we know almost nothing. They apparently burnt their dead. But he accepts on faith that with the introduction of iron a Celtic people came—a long-headed race, which gave the modern impress to the Scottish type. It is possible, as Sir William Turner agreed, that the human remains discovered by Dr. Edward Ewart on the shores of the East Lothian in 1911 may represent people of the early Iron age; in all their physical characters they are akin to the Scots of the Neolithic period. When Sir William Turner came to examine the skulls of the modern Scottish people he found that the cemeteries on the East Coast—particularly in Fife and in the Lothians—carried convincing evidence that the short-cist stock was not extinct. In some cases—particularly in Fife—there were communities in which the round-heads still formed 50 per cent of the inhabitants and more; of 79 skulls from cemeteries in the Lothians 25 per cent were brachycephalic, while amongst 31 skulls from Renfrew, on the western side of the country, there was not one. The course of twenty or thirty centuries had failed to diffuse the round-headed invaders of the Bronze age among the more ancient long-headed people of the west. He admitted that there must be a Welsh, a Danish, a Scandinavian, and a Saxon element in the modern Scottish, but he would have been the first to admit that the origin of the real bulk of the Scottish people—the descendants of Gaelic-speaking ancestors—remains still an enigma.

We have now to turn for a moment to the conclusions reached by the Anthropological School of the University of Glasgow. From his exploration of the chambered cairns of Arran and of the south-west of Scotland Prof. Bryce draws certain definite inferences.[9] He finds the prototype of their burial cairns in the north of Ireland; we may infer that 4,000 years ago or more there existed already a connection and intercourse between the peoples of the north of Ireland and the south-west of Scotland. He agrees that these chambered-cairn Neolithic folk were of the Mediterranean stock; their culture is of the South. He is further of opinion that when these cairn people were entering the back door of Scotland on the west the short-cist, round-headed people from the Continent were entering the front door on the east. The east and the west met in Scotland, but to what degree they mixed we have already seen from Sir William Turner's investigations. How far the west was left untouched by the round-heads, and the extent to which the English and the West Scottish have been evolved from a mixture of similar human stocks, have been brought out vividly by the investigations of Dr. Matthew Young, at one time assistant to Prof. Bryce. In 1916 Dr. Young published a monograph[10] describing the dimensions, characters, and variations seen in a collection of skulls—above 600 in number—derived from a comparatively modern burial ground in Glasgow. In this swatch of the modern population of that great city he found that the round-heads amounted to only 2.2 per cent, against 25 to 30 per cent presented by several cemeteries on the East Coast. The most remarkable result of his labors, however, was the discovery of a close similarity between the Glasgow skulls and the collection from Whitechapel described by the late Dr. W. R. Macdonell. The degree of resemblance will be seen by comparing some of the chief mean measurements of skulls of adult males:

	Max length mm.	Max. width mm.	Average height mm.	Bizygomatic width of face mm.	Length of upper face mm.
Glasgow.....	187.5	139.5	117.0	127	70.9
Whitechapel.....	189.06	140.6	114.59	130	70.1

We are not surprised to note that the Scottish face is somewhat longer and narrower, but we were not quite prepared to find that the Londoner had the larger head. Nor need we really be surprised to find so close a similarity between samples of the population culled from the

*From *Nature*.

[1] "Prehistoric Remains of Caithness." By Samuel Laing, M.P. (1866.)

[2] "The Cairns of Arran." Proc. Soc. of Antiq. of Scotland, 1902, p. 75; *Scottish Historical Review*, 1905, p. 275.

[3] "The Races of Ireland and Scotland." (1906).

[4] "The Story of the British Race." (1899.)

[5] See Proceedings of the Anatomical and Anthropological Society of Aberdeen University of December, 1902, and subsequent dates.

[6] "The Archæology and Prehistoric Annals of Scotland." By Daniel Wilson. (1851.)

[7] "Physical Characters of the Adults and School-children of East Aberdeenshire." By John Gray and James F. Tocher, Journ. Roy Anthrop Inst., 1900, vol. xxx., p. 104.

[8] "Contributions to the Craniology of the People of Scotland." Part i. Trans. Roy. Soc. Edin., 1903, vol. xl., p. 547; part ii., 1915, vol. li., p. 171."

[9] *Scottish Historical Review*, April, 1905, p. 275; Proc. Soc of Antiq of Scotland, 1902, p. 75.

[10] "A Contribution to the Study of the Scottish Skull." Trans. Roy. Soc. Edin., 1916, vol. li., p. 347.

Clyde and from the Thames estuaries when we remember that since the close of the Bronze period British invaders and immigrants have invariably been members of the Nordic stock. We do not know when that stock first settled in Britain, but it is difficult to account for all the facts now at our disposal unless we accept Huxley's hypothesis that it reached Britain very early—probably, as Prof. Bryce supposes, at an early Neolithic or even more ancient date.

Osmotic Pressure*

By Prof. W. C. McC. Lewis, M.A., D.Sc.,
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ALTHOUGH the concept of osmotic pressure has played an outstanding part during the last thirty years in the development of physical chemistry, it is a remarkable fact that even at the present time no very general agreement has been reached as to the actual mechanism of the phenomenon itself. The view that osmotic pressure is a simple bombardment pressure identical in nature with the pressure exerted by a gas, the dissolved substance functioning as a gas and bombarding the semipermeable membrane, has long been held, though not without considerable scepticism on the part of those who rightly maintained that a solution was after all a liquid in the ordinary sense of the term, and that in a system of this nature we have to deal with forces the magnitude of which is extremely large. Undoubtedly the simple bombardment view owes its popularity to the very simple and obvious explanation which it offers of the fact that the gas law holds good for the dissolved substance in dilute solution, a fact first discovered by the eminent Dutch physical chemist van 't Hoff. On the other hand attempts have not been wanting to show that van 't Hoff's law is the limiting expression of a more complicated law which can be derived by regarding the phenomenon of osmotic pressure as primarily connected with the *solvent* and only in a secondary sense with the dissolved substance. One of the most recent attempts in this direction, and one which is at the same time eminently successful, is that of Tinker, briefly outlined in the *Phil. Mag.* vol. xxxii. p. 295, 1916, and the *British Assoc. Rep.*, 1916. Tinker bases his considerations on the Dieterici equation of fluids. According to Dieterici a pure liquid possesses what may be called a liquid pressure—when the liquid is acting as a solvent we may call this pressure the solvent pressure—denoted by the symbol π, which is connected with the free or unoccupied space in the liquid and with the temperature by the ordinary gas law. Thus if we denote the volume of the liquid by V and the occupied space by b, then the free space is V-b and the pressure π is related to this free space by the equation $\pi(V\text{-}b) = RT$.

This solvent or liquid pressure is itself a bombardment pressure due to the kinetic energy of the moelcules of the liquid, the pressure being exerted on any imaginary unit area in the interior of the liquid. It is a quantity which cannot be measured directly, for any direct measurement involves a contact surface at which the observed bombardment pressure is very much less than π. As a matter of fact π may be several hundreds or thousands of atmospheres, while the bombardment pressure actually observed is exceedingly small. The vapor pressure of the liquid, in fact, gives us a measure of this latter quantity. The reason why the observed bombardment pressure is so small is, that when a molecule approaches the surface it is drawn back by strong unbalanced forces of attraction which tend to prevent it passing across the surface. In the interior of the liquid, on the other hand, these forces, though still as strong as before, mutually destroy one another and the molecule is free to exert an enormous bombardment pressure at an imaginary plane. Exactly the same thing may be said of the molecules of the dissolved substance, though on account of their smaller concentration in the interior they exert there a correspondingly smaller pressure. At the free surface of the solution the molecules of a solute such as sugar are so effectually drawn back that even their vapor pressure is immeasurably small. It is very reasonable to assume that a similar state of things holds at the surface of a membrane enclosing the solution, and if this be so, it is evident that the bombardment pressure of the solute upon the membrane must be quite negligible, and cannot therefore account for the observed osmotic pressure.

We now come to the problem of how to account for the phenomenon of osmotic pressure at all. For the sake of simplicity we shall restrict ourselves to the ideal solution; the ideal solution being one in which the volume of the mixture is exactly equal to the sum of the volumes of the two constituents separately. In such a case the fundamental idea advanced by Tinker is that the *solvent* pressure in the solution is *less* than the *solvent* pressure in the pure solvent itself which lies on the other side of the membrane. To see how this might occur, let us think of equal volumes of two separate gases, A and B. If these are mixed, and the resulting volume is just double the original volume of either, it follows that partial pressure of each constituent—say the substance A—in the resulting mixture is exactly half of its value in the original state. It is to be observed that this diminution in the pressure exerted by A is brought about, although the effective space occupied by any single molecule is just the same before and after mixing, *i.e.*, the space per molecule $= \frac{\text{total number of molecules}}{\text{total volume}}$ and in the case considered we have doubled the number of gas molecules and doubled the volume at the same time. To return to the case, of the solution, the partial liquid pressure of the constituent, which we call the solvent, is diminished by the presence of the solute, for exactly the same reason that the partial pressure of the gas A was diminished.

If therefore the solvent and solution are separated by a membrane, permeable to the solvent, impermeable to the solute, the solvent pressure on the pure solvent side is greater than the solvent pressure on the solution, and therefore some solvent is forced into the solution. That is, the phenomenon of osmosis occurs. Further, we can apply an external pressure to the surface of the solution by means of a piston or an inert gas, and so prevent osmosis taking place. This applied pressure is numerically equal to the osmotic pressure of the solution, and, in fact, the method is employed experimentally to determine osmotic pressure. By compressing the solution in this way we obviously diminish the free space in the solution, and, therefore, cause the solvent pressure in the solution to rise, until it is equal to the solvent pressure in the pure solvent itself, and no further osmosis can take place, *i.e.*, the solvent is now passing in and out of the membrane at the same rate.

Now we know that liquids are very imconpressible. It follows therefore that there must be very little free space in liquids. If this were not the case, it would be quite inconceivable that the application of an external pressure of a few atmospheres by the piston could sensibly affect the free space, and, consequently, the value of the solvent pressure. As a matter of fact, the free or unoccupied space in a liquid is about one-fifth to one-tenth of the total volume occupied by the liquid.

It is thus seen that the osmotic pressure may be explained as due to a difference between the value of the solvent pressure π in the pure solvent and the value of the solvent pressure π' in the solution. This is the new concept of osmotic pressure, especially for solutions which approximate to the ideal case. In the case of non-ideal solutions the osmotic pressure is a more complex phenomenon, but the underlying idea is the same. It is not proposed to enter into the case of non-ideal solutions in this place. One point only remains to be considered in connection with the ideal solution.

It has been stated, that the osmotic pressure depends upon the difference of the π values. This must not be taken as meaning that the osmotic pressure P is simply $\pi\text{-}\pi'$. The actual relation between them is easily shown to be, in the case of a dilute solution:

$$P = \frac{RT}{V}\,\frac{\pi - \pi'}{\pi'}$$

where V is the volume of one grammolecule of the solvent and R is the gas constant. Tinker has shown further that this expression leads at once to the van 't Hoff law for the osmotic pressure. The new concept of osmotic pressure is therefore quite in agreement with the striking experimental facts demonstrated by van 't Hoff and is capable of accounting for them in a satisfactory manner. We are therefore no longer tied to the bombardment view which attributes the osmotic effects to a simple gas pressure exerted by the solute. Several other relationships, which cannot be discussed here, may likewise be deduced, with the help of the concept of solvent pressure. The position is therefore a hopeful one and it may not be long before we possess a really comprehensive and satisfactory theory of dilute solutions not simply from the thermodynamic standpoint but from the molecular standpoint as well.

*Science Progress.

Spruce Shortage a Big Problem for Air Board

LATE reports from Washington state that success in carrying out the program of the Aircraft Production Board depends upon getting out the wood for the wings and bodies of aeroplanes. The most suitable wood possessing all the essential qualities for such construction is Oregon and Washington spruce. It is stated that while there is no dearth of such timber the demand for it during the past three years has increased so greatly as to exceed the capacity for production. Prior to the war this class of stock brought about $100 per thousand, but the Allies having used it almost exclusively in the construction of their aircraft since the outbreak of the war, the demand has caused the price to rise to $200 per thousand.

The average aeroplane requires not more than two hundred feet of wood for its construction, but until the recent standardization in sawing specifications was affected by the conference between the representative of the Spruce manufacturers and the aircraft experts of the Allied governments and the United States it had been necessary to cut approximately one thousand feet to get out the desired amount of timber for one aeroplane.

Constant efforts are being made to find some other wood that can be substituted for spruce, but up to the present time none has been found which combines the qualities of strength, lightness and flexibility, each of which is absolutely essential and all of which are possessed by spruce.

After being turned out of the mills the wood must be thoroughly dried before it is available and that has been done heretofore in the open air, which has required several months. It is believed, however, that two processes have been found recently by which the wood can be dried in kilns without reducing its flexibility. If the processes prove to be a success it will mean a great saving of time in manufacture and will enable the manufacturers to speed up the production of aeroplanes. In view of the fact that speed is a most important factor to the success of the United States and its allies in obtaining permanent dominancy of the air, the value of the processes cannot be overestimated.

Difficulties in transportation arising from the constant demand for freight cars constitute a serious handicap in carrying out the programme of the Board. The factories at which the aeroplanes are being constructed or at which the various parts are being assembled are located principally in the Middle West, but it is believed that none of those that may be erected will be located in the Far West, because it is less expensive to transport the raw material than the finished product.

The output of this class of spruce for the year 1916 was 33,000,000 feet, virtually all of which was used in the construction of aircraft. This year, in order to meet the enormous demand created by the program of the United States, the production must be greatly in excess of that amount.

It is conceded by officials familiar with the situation that there are great difficulties to be overcome and that no certain method except indefatigable effort has yet been devised for assuring success.

One of the results accomplished by the conferences between the lumber men and the aircraft experts was that the former offered to make the price of $105 a thousand for Spruce, and it is believed the War Industries Board will recommend the acceptance of a figure approximating that amount. —*The New York Lumber Trade Journal.*

Desert Spermophiles

STATIONED about one mile from Douglas, Ariz., during the border trouble last summer, the writer had occasion to notice the activity of the ground squirrel (*Ammospermophilus?*). This little animal, although very abundant in the locality of camp, was so exceedingly shy that only a few specimens were taken. However, if many had been wanted their apparent hunger would doubtless have made them easy prey for traps.

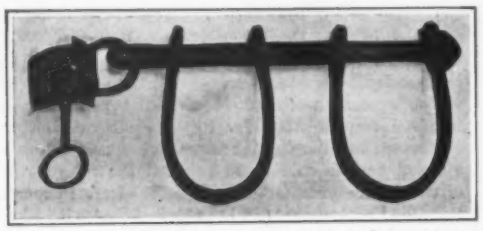
From the living tents of the command to the picket line where the horses were staked out, was an open space of about fifty yards, and this space was literally riddled with their burrows.

One morning one of the men called to me saying that he thought he had one of the ground squirrels trained.

Taking my camera, I hurried out and found a group of the men around one of the burrows with the "trainer" drumming with his fingers just about it. One of the pictures thereupon taken shows one of the men drumming over the hole.

It was necessary to exercise patience, but at last we were rewarded by the appearance of the ground squirrels, sometimes as many as three at a time. They would hurry out and scamper all around the burrow, until someone moved. It was vital for the success of the scheme to keep very still, for at the slightest sound they would scurry into the holes again. If they became frightened when far away from their own burrows, they would run away from them, and into any other one that happened to be close at hand. This fact led me to believe that they must have had a sort of communicating passage between some of the numerous burrows.

If the hand were held very still, the ground squirrel would come right up and eat any green leaf that was offered it, but the slightest move sent it pell mell down the hole.—ROBERT SUTCLIFFE, Staff, New York Aquarium in N. Y. Zoological Soc. *Bulletin.*



Wrist-bolts or hand-cuffs of early pattern, employed to restrict the movements of a prisoner.

A formidable iron man-trap, such as was once legally set to catch a trespasser.

Iron manacles for waist, ankles and wrists, by means of which prisoners were made submissive.

A "Brank" or "Scold's Bridle." Note the nose-hole, also the iron plate which went into the mouth over the tongue.

An old guilded "Staff;" also the metal case in which it was kept. Carried in the wallet as evidence of authority.

An old prison bell cast in 1775 for Newgate prison London, and tolled as a felon was conducted to the scaffold.

Anotheer "Brank," giving a better view of the manner it was fitted to the head of a scolding woman, and padlocked.

Relics of Old-Time Justice

Rough and Ready Methods of the Simple Life of Our Ancestors

By Percy Collins

RECENTLY the writer was privileged to examine a collection of objects which emphasize, in a remarkable manner, the changes which have taken place in the administration of justice among the civilized races of mankind. Nowadays the chief aim of justice is the reclamation of the evildoer. It is concerned far less with the mere punishment of crime than with the uplifting of the criminal class. Yet this change is of comparatively recent date. Little more than a hundred years ago the treatment meted out to malefactors remained almost brutal in its severity; while if we go back still farther, we find relics of justice—such as the pillory, the stocks and the tumbrel or ducking stool—which are little better than implements of torture.

Among the most astonishing devices for inflicting degrading punishment are the so-called branks, or scolds' bridles, of which numerous examples are still in existence. They are not of very great antiquity, few being known earlier than the end of the sixteenth century. One of the earliest authentic specimens is preserved in the Church of Walton-on-Thames, England. It bears the following couplet:

"Chester presents Walton with a bridle,
To curb women's tongues that talk so idle."

Tradition states that it was presented to the town by a gentleman named Chester, who had suffered the loss of an estate through the mischievous babble of a gossiping hag. A scold's bridle consists essentially of a wrought iron framework capable of being fixed round the head at the level of the mouth. There is an opening to admit the nose, and an iron plate, or gag, which projects above the tongue when the contrivance is in use. The bridle was usually secured by a small padlock, while a chain was commonly attached, by which the victim was led about the streets of the town or village, so that the whole community might witness her shame. If she refused to walk, or was too feeble to do so, she was wheeled about in a barrow, or attached to some stump or monument in a public place, and exposed to the pitiless treatment of the mob. Strange as the fact may appear in the light of modern clemency the scolds' bridles were once common throughout the length and breadth of Great Britain, and a justice of the peace sanctioned their use with no more ado than a magistrate of today imposes a small fine. For some inexplicable reason, the implements which were in use in the north appear to have been far more tormenting than those of the south. At Forfar, in Scotland, there was a fearfully severe brank which was placed on witches when they were being led out to be burnt at the stake—doubtless with the object of preventing the poor witch from imparting the secrets of her black art.

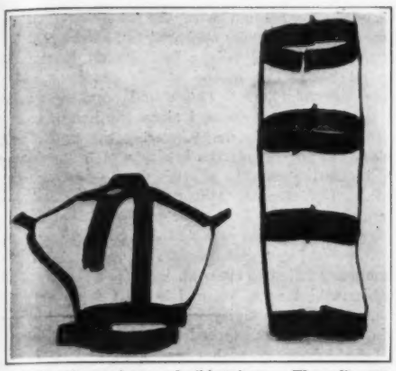
The hand-cuffs, wrist-bolts and manacles which were employed to restrict the movements of a prisoner—possibly a mere suspect, whose guilt was still unproved—were often brutal in the extreme. Several examples are shown in the accompanying photographs. In one case curved and slotted pieces of metal were placed over the wrists, a bolt being then run through the slots and padlocked into place. Another specimen is especially diabolical in design. These wrist-bolts are wrought in two pieces, hinged, and with a screw lock. When in use they held the wrists of the captive close together, either before or behind the body, in such a position that he must have suffered agonizing pains. Iron manacles for the waist, wrists and ankles were also in common use, and were often forged into place, so that the wearer could only be freed from them by the use of chisel and hammer. It should be added, however, that these heavy irons were probably reserved for condemned criminals or military prisoners.

The use of the phrase "hanging in chains" to describe the gibbeting of criminals is somewhat misleading, for although chains were no doubt occasionally employed for this purpose, the bodies appear generally to have been suspended in a frame work of hoop iron, made by the local blacksmith. Authentic specimens of these gibbet irons, as they were called, are shown in an annexed photograph. These are known to have been used to suspend the body of a notorious felon after his execution on the 2d of February, 1787. The relics consist of a head-piece, and a leg-iron or case for the leg. The swing-hook of the head-piece, by means of which the whole framework was attached to the gibbet, is missing; so also is the neck rivet, which was probably removed in order to take away the skull—possibly by some relative or friend of the deceased, with the object of giving decent burial to the bones after popular indignation had subsided.

The practice of gibbeting was common during the Middle Ages, the object of this barbarous custom being to set before the eyes of the common people a warning against crime. But human life was held cheap in those days, and there is no evidence that the fear of death proved an effective deterent. Hangings were everyday occurrences; "liberty of galloes"—*i.e.*, the power to pass sentence of death—was frequently a manorial right; and executions were as often as not made the occasion for public feasting and merry-making. In passing, it should be noted that female felons were usually drowned, and for this reason a pond was frequently associated with the gallows. The old prison bells, which were tolled as the felon was conducted to the scaffold, possess a gruesome interest. Perhaps the most notable is that which was cast by Pack and Chapman, in 1775, for Newgate Prison, London. When in 1903 the prison was rebuilt, this bell, together with the condemned cell fittings, was bought for Mme. Tussaud's famous exhibition for the sum of £100.

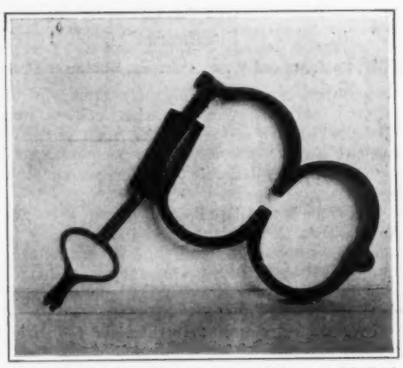
The right to inflict punishment for crime is today vested exclusively in the law, which is interpreted by impartial judges—executive officers whose integrity is beyond suspicion. But the experience of many centuries was needed to establish this ideal. In mediæval times the proprietary class possessed well-nigh limitless powers to protect and enforce their rights; while in comparatively recent years the landowner was still legally entitled to set spring guns and man traps within the confines of his domain—an act of trespass being deemed sufficient pretext for the infliction of bodily injury. A spring gun was often a formidable weapon, heavily charged with shot, the trigger being attached to wires which were stretched among the undergrowth in several directions. The gun was usually provided with a revolving swivel, so that the discharge was directed to that point of the compass where the wire was disturbed—the object being to wound the trespasser in the legs, thus preventing his escape. Still more brutal was the man trap—a contrivance which resembled the modern rat gin on an enormously magnified scale. Armed with terrible steel teeth, and actuated by a powerful spring, it was sufficiently powerful to break the leg of the poor wretch who was unlucky enough to set his foot upon the trigger-plate. The trap, when set, was chained to a stout peg driven into the ground, and was carefully hidden beneath a litter of moss and leaves.

In those days of rough-and-ready justice, every householder of importance possessed his blunderbuss—a

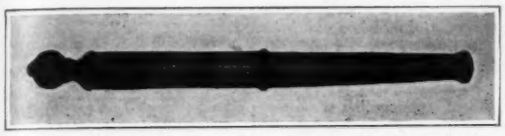


Authentic specimens of gibbet irons. The relics consist of a head-piece and a leg-iron or case for the leg.

An old watchman's rattle used by one of the ancient "Charlies" to scare away burglars or to call for assistance.



A pair of wrist-bolts with a screw lock. A diabolical species of hand-cuff which almost produced torture.



Heavy wooden truncheon, an old implement carried by the "peeler" or police officer.

Spring-gun, with attachment for firing. An old-time weapon for dealing with trespassers.

Blunderbuss. A safeguard against burglars, and at one time found in every house.

Relics of Old-Time Justice

clumsy weapon, with flint lock and naked powder pan. This was discharged on slight pretext; and if the effect was not deadly, the sound of the explosion at best served to call up assistance. The clumsy wooden rattle was also serviceable as a means of attracting attention at a period when a man, confronted by emergency, relied chiefly upon the help of his immediate neighbors. But the rattle is also interesting because it constituted an important part of the old-time watchman's personal equipment.

These men, often muddle-headed and decrepit, were nevertheless the primitive forerunners of our modern police force. Later came the "peelers" with their heavy wooden truncheons. The latter implements, by the way, must not be confounded with the ornate and gilded "staffs" which were carried in the pocket or wallet, and were the bearer's evidence of authority. Students of Charles Dickens will remember how, in the "Pickwick Papers," the special constables who accompanied Mr. Grummer were each furnished with one of these staffs.

Modern Locomotive Practice*

By T. A. Foque

In passenger service the locomotive best suited to present-day requirements is the 4-6-2, or Pacific type, which is almost universally used where a tractive effort of from 42,000 to 45,000 pounds is required. Where very heavy grades are encountered, or where long, heavy trains are operated on even moderate grades, the 4-8-2, or Mountain type of locomotive, is becoming popular.

In freight service 2-8-2, or Mikado type, is now largely used in place of the 2-8-0, or Consolidation engine, where a tractive effort of from 50,000 to 60,000 pounds is required. With a 63-inch driving wheel it is not only good for heavy freight service, but is well adapted to fast freight work. On lines with very heavy grades this type of engine, with the addition of a fifth pair of driving wheels, is designed for a tractive effort of from 65,000 to 83,000 pounds and is known as the Santa Fe type. Increased boiler capacity and factor of adhesion make this type of engine better for heavy slow service than the Mikado type.

On exceptionally heavy grades, extending over a large portion of a division, Mallet compound engines are quite generally used in 2-8-8-0 and 2-8-8-2 types. The tractive effort of existing engines runs from 91,000 to 103,000 pounds.

For pusher service over heavy grades triple-compound types 2-8-8-8-2 and 2-8-8-8-4, are now being used by two railroads. These have two high-pressure and four low-pressure cylinders, and the rear set of driving wheels and truck are located under the tender.

One road is now experimenting with a 2-8-2-2-6 type of engine, consisting of the application of the running gear and machinery from a retired Mogul locomotive to the tender of an existing Mikado locomotive.

In switching service the ordinary or 0-6-0 type is in most common use, but some 0-8-8-0 Mallets with a tractive effort of 100,000 pounds are now being used in hump-type classification yards. Considerable time is saved on account of taking trains just as delivered by road engines and putting them over the hump and classifying. For heavy general switching service the 0-8-0 type, running up to 70,000 pounds tractive effort, is used with success.

Comparatively few locomotives are now built without a super-heater. The economy following the use of this device is very marked and existing engines have been greatly improved by the addition of the device. To reduce the fuel consumption further the use of brick arches supported on water tubes is very common, and modern improvements in the design of the arches have made their use practical where formerly they gave considerable trouble.

On all road locomotives and some switching locomotives, outside valve gear of the Walschaerts type is used almost altogether. Accessibility, better distribution of steam and freedom from breakdowns make outside gear very desirable. On the Soo Line we have modified the ordinary type of gear by taking our motion for the lap-and-lead lever from the main rod instead of the crosshead. This is quite a marked improvement in that it gives us much better port openings.

The majority of engines now built are so heavy that the usual form of reversing mechanism is not suitable, and power reverse gear, either of the screw pattern or operated by steam, has been introduced with very satisfactory results.

Pneumatic fire doors relieve the fireman of much work and are beneficial to an engine in that they greatly reduce the time in which a door is kept open.

One of the great troubles with heavy locomotives is found in the design of the main driving boxes and the brass in the ordinary type of box may be renewed two or three times before an engine requires a general shopping. To eliminate this expense and wear on an engine, boxes 20 inches long or longer are now used on the main journals.

The old practice of keeping steam pipes within the smoke-box has nearly been done away with, and we now use outside pipes to the steam chest, eliminating in a large measure the trouble with leaky joints and giving us easier access to the smokebox appliances.

The advent of long freight trains called for air compressors of much greater capacity, and we now use two single-stage pumps or one compound pump.

In recent years much more attention has been given to proper air openings in the ashpans and dumping mechanisms which will allow of frequent and easy disposal of the cinders. On some large locomotives, especially where a low grade of fuel is used, the work of firing has become too much for one man and mechanical stokers are now being used, and some of them are now doing very good work.

Within a year or two a few roads have experimented with an apparatus for burning pulverized fuel. The question is one of much interest, for there are in certain parts of the country large deposits of fuel wholly unsuited to locomotive use in its present form, but which may in powdered form prove not only satisfactory but very economical.

In locomotive tenders the tendency today is toward those of large capacity, which frequently permits of the avoidance of water supplies which are exceedingly bad. To save labor and because of legislation, tenders are now constructed with coal hoppers of such design that the coal will automatically be placed within easy reach of the fireman. Hoppers which cause the coal to come down and forward by gravity are the cheapest and best, but in some cases mechanical coal pushers have been installed.

Special attention has been given for a number of years to truck design, with a view to eliminating dangerous roll at high speeds. In many derailments the forward tender truck is the first to leave the track. Comparatively slight depressions in the track may set up a rolling of the tender, which, accompanied by a reverse roll of the locomotive, will cause the forward tender wheels to jump. The connections between the locomotive and tender also have a bearing on this, and one connection has been designed which is a vast improvement over anything used before.

Important as is the design and construction of a locomotive, the vast majority of troubles in locomotive operation may be found in lack of maintenance. In certain parts of the country we are sorely tried with water heavy with incrusting salts. It is not an easy matter to handle bad water successfully, but in most cases it can be done. In repairs to machinery there is but one sensible and economical course to follow: when defects appear, apply the remedy. It has been demonstrated without question that it is more economical to keep up the running repairs and not wait until a locomotive needs a general shopping.

*Journal of the American Society of Mechanical Engineers.

Selenium Cell as Burglar Alarm

Under the trade name "the electric eye" Dr. O. Hannach, of Berlin, is introducing a sensitive selenium cell, which will give a signal, when it is illuminated by the flame of a match, at a distance of 10 m. The selenium cell acts in the usual way as a relay. The cell is small (*Elektrotechnische Zeitschrift*, May 3d, 1917), and can easily be hidden in the decorations of a safe or piece of furniture and covered with glass. The advantage claimed over ordinary burglar alarms is that the device will operate as soon as a light is introduced into the dark room, while other alarms have to be excited by the breaking of an electric circuit or by mechanical vibrations. As the electric eye works with a suspended coil, however, accidental vibrations might make it more sensitive than is desired.

Poles for Electric Transmission Lines

In laying out an electrical transmission line the question of poles is an important one, for not only is the question of first cost involved, but the character of the district through which the line runs must be considered in relation to the cost of maintenance. Wooden poles are often the cheapest, but are not always strong enough to support heavy modern lines, in which case it becomes a question between steel construction and reinforced concrete. In some localities there is such a volume of destructive fumes discharged into the atmosphere as to seriously affect steel structures, and the cost of repairs may be very heavy, even where the best protective paint is used, and if the proper wooden poles cannot be obtained at a reasonable cost it is often found desirable to use reinforced concrete construction.

The Photoelectric Sensitivity of Various Substances*

W. W. Coblentz and W. B. Emerson, Bureau of Standards

SOME time ago an examination was made of various substances to determine their electrical sensitivity to light; and in view of the fact that some of the results, obtained are at variance with the measurements made by Case,[1] it seems desirable to publish a summary of our observations.

Two of the herein described substances were examined for change in electrical conductivity caused by the action of light upon them, and all of them were examined for photoelectrical activity when they were charged to a negative potential in an evacuated bulb and exposed to light.

When the substances were examined for an increase in electrical conductivity, a potential of 2 to 6 volts was connected through a resistance of zero to 100,000 ohms into a circuit containing a d'Arsonval galvanometer and the substance under investigation. In most cases the substances were slightly conducting when not exposed to light, so that the "dark current" had to be annulled by joining a counter e. m. f. through a resistance of 10,000 ohms to the terminals of the galvanometer. This counter e. m. f. was obtained by shunting across a resistance of 100 ohms which was in series with a cell of 2 volts and a variable resistance of zero to 70,000 ohms.

The source of light, when not otherwise specified, was a 16-c. p. carbon incandescent lamp, placed at a distance of 10 cm. from the substance under investigation. One disappointing feature of this investigation is that no substance was found which is comparable in sensitivity with the potassium photoelectric cell and with the selenium cell.

SUBSTANCES EXAMINED

Gallium.—The material examined was the highly purified metal prepared and supplied by Dr. H. S. Uhler. This metal was solid, thus differing from the impure material, which is a liquid. It was melted and solidified over a platinum wire sealed into a glass bulb, thus forming the negative electrode of a photoelectric cell from which the air was exhausted. The anode was a loop of platinum wire, situated at a distance of about 12 mm. above the gallium electrode.

A potential of 340 volts was applied to the cell which was connected to a sensitive iron-clad Thomson galvanometer ($i = 5 \times 10^{-10}$ amp.).

The results obtained proved disappointing, this metal being quite insensitive to light. When the cell was exposed to daylight the photoelectric current produced a deflection of only 4 to 5 mm., whereas similarly exposing a potassium photoelectric cell the photoelectric current was sufficient to give a deflection beyond the range of the scale.

Silver Sulphide.—The sample examined was a thin flexible strip, 6 by 10 mm. in area, prepared by Mr. G. W. Vinal.[2] In one test the silver sulphide formed the negative electrode of a photoelectric cell (evacuated glass bulb about 5 cm. diameter with a ring of platinum wire for the anode) similar to the gallium cell just described. It was connected through an iron-clad Thomson galvanometer to a battery of 340 volts. When exposed to daylight a deflection of perhaps 1 to 2 mm. was observed, but no deflection resulted from exposure to the standard carbon lamp.

In the second test, copper wires were melted to the ends of a strip (3 by 5 by 0.3 mm.) of silver sulphide which was connected in series with a high resistance, a storage cell of 2 volts, and a d'Arsonval galvanometer. When exposed to the standard lamp, the galvanometer deflection was 10 mm. In another sample about 2 cm. long, the ends joining the copper wires were covered to prevent thermoelectric currents. The exposed aera was 14 by 4 mm. The radiation from the standard lamp produced a deflection of 13 to 17 mm. Both samples were quick acting, and after exposure to light there was no lag such as obtains in selenium in recovering its dark resistance.

Selenium.—A crystal of selenium, prepared by Dr. F. C. Brown[3] and having a receiving surface of less than one sq. mm., when exposed to the standard lamp gave a deflection of more than 50 cm., which shows its great sensitivity as compared with other substances.

The mounting of the selenium crystal consisted of metal electrodes between which the crystal was held by compression. When operated as a photophone, by connecting the selenuim crystal with an audion amplifier a loud musical note was obtained.

Tellurium.—This metal is said to change in resistance when exposed to light. The present tests were made upon a mirror of tellurium deposited upon a glass plate by cathode disintegration. Suitable terminals were attached to a sample about 4 by 50 mm. No change in conductivity was observed when it was exposed to light.

Boleite.—The sample of boleite [3Pb Cl (OH).CuCl (OH)×AgCl], from Boleo, Mexico, examined was a single rectangular crystal 3 by 3 by 1.5 mm. It was held by compression between copper electrodes. No change in conductivity was observed when the crystal was exposed to daylight or to the standard incandescent lamp.

Stibnite.—Samples of this same specimen of stibnite, Sb_2S_3, were supplied to Elloit[4] for investigation. The purpose of the present investigation was to obtain a comparison of its sensitivity with that of other substances containing antimony.

The size of one sample examined was 4 by 7 by 0.5 mm. Terminals were attached to it by heating a copper wire to incandescence in a gas flame and bringing it in contact with the plate of stibnite.

The standard carbon lamp caused a deflection of 5 cm. Stibnite may be considered as sensitive as boulangerite, to be mentioned presently, but the deflection drifted, due to the decrease in resistance with time already noticed by other observers.

Boulangerite.—The specimen of boulangerite (3PbS. Sb_2S_3, Irkutsk, Siberia) investigated was obtained from the Smithsonian collection, No. 78395. Several samples were examined. In one sample, 4 by 7 by 0.8 mm., the electrodes consisted of copper wires melted into the material as just described. The radiation from the standard lamp gave a deflection of 10 to 20 cm.

Another sample, 1 by 1.2 by 2 mm., held by compression between two heavy electrodes of copper, when exposed to the standard incandescent lamp produced a deflection of 2 to 3 cm., which is comparable with the preceding when one considers the size of the exposed surfaces.

Although this substance seems fairly sensitive, it did not appear to be sufficiently so to justify an investigation of its spectral sensitivity with a view of using this mineral as a selective radiometer.

Jamesonite.—($2PbS.Sb_2S_3$; Smithsonian collection No. 12,500; from Cornwall, England.) The sample examined (size 2 by 7 by 1 mm.) had the copper wire terminals attached by fusing the incandescent wire into the material. The standard lamp gave a deflection of only 1 to 2 cm., which seems to indicate that this material is not so light-sensitive as in boulangerite.

Mixtures of galena, PbS, and stibnite, Sb_2S_3, in various proportions were melted in a crucible and poured upon a plate of metal. Several samples, 5 by 10 by 0.5 mm., were examined, but none of them gave any indication of light-sensitiveness (change in resistance) when exposed to daylight or to the standard incandescent lamp.

Bismuthinite.—Bismuthinite, Bi_2S_3, was obtained from the Smithsonian collection, No. 85071, from Jefferson County, Montana. This is the most interesting substance examined, in view of the diverse results obtained and the explanation offered therefor.

The sample of bismuthinite examined consisted of a non-homogeneous mass of acicular crystals, which was easily crushed into numerous fine needle-like crystals. The first sample examined was a small mass of crystals (size 1 by 1 by 0.7 mm.) held by compression between two heavy electrodes of copper. When the crystal was exposed to the standard carbon lamp no change in conductivity could be detected with certainty.

A second sample, 3 by 6 by 1 mm., had the copper wire terminals attached by fusion, as already described. The e. m. f's applied were the same as for the preceding sample. When exposed to the standard lamp no change in conductivity was observed. These results being contradictory to those published by Case[5] who used a three stage audion amplifier to detect the change in conductivity of the crystals, the foregoing experiments were repeated in the manner described by him. For this purpose the light from an acetlyne flame shining through a slit 2 by 10 mm. was focussed upon the crystal by means of a triple achromatic lens, 6 cm. in diameter and 18 cm. focal length. The light was interrupted by means of a sectored disk having 15 openings and operated by means of an electric motor, the speed of which could be varied. The usual speed gave 240 interruptions per second. The crystal was connected to a three stage audion amplifier and telephone receiver. A crystal of selenium or a selenium cell produced a loud note, but the samples of boulangerite and jamesonite, which by previous tests were light-sensitive, did not give a musical sound in the telephone.

The sample of bismuthinite with electrodes sealed on produced no audible note when exposed to light.

At least a dozen samples of bismuthinite held by compression between heavy copper electrodes were examined in connection with the amplifier. Of this number only two samples appeared to be light-sensitive. One sample produced only a faint sound in the telephone receiver. The second sample produced a loud note in the telephone. The sound was the loudest when the crystal was exposed along the line of contact with the copper electrode. Covering the crystal with red glass did not reduce the loudness of the note very much, indicating that the effect is due to heating of the material. Unfortunately, this crystal was crushed while under investigation. Prolonged tests on other samples gave negative results as regards the production of sound.

In view of the fact that the tests made with a sensitive galvanometer failed to show an increase in conductivity when bismuthinite was exposed to light, it appears that the change in conductivity which was observed when a certain specimen was exposed to intermittent flashes of light (photophone or, rather, radiophone) is the result of a thermal change within the crystal, or perhaps a change in the contact resistance at the electrodes.[6] In this connection the following experiments on thin strips of metals are of interest.

Platinum and Gold.—In conclusion it is of interest to record the results obtained when using thin blackened strips of platinum and of gold-leaf as radiophones, by connecting them through a battery to an amplifier.

These blackened strips were warmed intermittently by exposing them through a rotating sectored disk to the acetylene flame, as already described.

When a sensitive platinum bolometer receiver was used as a radiophone, the sound produced in the telephone was not very audible. This no doubt was due to the great heat capacity of the material which prevented the rapid alternations in resistance, and hence in electric current, from being of sufficient magnitude to affect the telephone receiver.

Using a lightly smoked strip (6 by 2.5 mm.) of gold-leaf, the ends of which were clamped between thin (0.02 mm.) strips of tin, the sound produced in the telephone receiver was as loud as was observed in the photophone made of selenium.

This device was mounted in a glass bulb which could be evacuated. As was to be expected, there was no marked difference in the intensity of the sound produced when operated in air and in a vacuum.

In the gold-leaf radiophone as used, the limit of audibility was attained for a light (radiant power) intensity of 4.8×10^{-5} watts. Using a larger receiver and amplifier and a larger current (which was 0.2 amp. in the present tests) through the receiver, the sensitivity could be greatly increased.

SUMMARY

This paper summarizes the results of an investigation of various substances (1) for an increase in electrical conductivity caused by the action of light upon them, and (2) for electrical discharging activity when they were charged to a negative potential in an evacuated chamber and exposed to light.

Pure gallium and silver sulphide were found to have but small photoelectric discharging action when charged to a negative potential and exposed to light.

No change on exposure to light was observed in the electrical conductivity of tellurium, boleite, bismuthnite, and mixtures of the sulphides of lead and antimony.

An increase in electrical conductivity on exposure to light was observed in crystals of selenium, stibnite, boulangerite, jamesonite, and silver sulphide.

Experiments are described in which crystals of bismuthinite were joined through a battery to the grid circuit of an audion amplifier and a telephone. A change in current in this circuit affected the telephone. The light stimulus was interrupted by means of a rotating sectored disk, as used in Bell's selenium photophone. When using a cell or crystal of selenium the fluctuations in light intensity produced a sufficient change in conductivity to cause a musical note in the telephone. Similarly, in several samples of a crystal of bismuthinite a change in conductivity was produced, which caused an audible sound in the telephone. However, from various tests it is believed that this is not a true photoelectrical change (increase) in conductivity, but is due to a thermal resistance change within the crystal or to a change of resistance at the point of contact of the crystal with the metal electrodes between which the crystal was held by compression.

Experiments are described in which a thin blackened strip of platinum or of gold-leaf is joined through a battery to an audion amplifier. The variation in temperature and hence in the resistance of and in the current through the strip, caused by the fluctuation in intensity of the intermittent light, was sufficient in magnitude to produce an audible sound in the telephone receiver.

*Journal of the Washington Academy of Sciences. To be published in full in the *Bulletin* of the Bureau of Standards.

[1] CASE. Phys. Rev., 9: 305. 1917.

[2] VINAL. Bureau Standards Scientific Paper No. 310.

[3] BROWN Phys. Rev., (2) 4: 55. 1914.

[4] ELLIOT. Phys. Rev., (2) 5: 53. 1915.

[5] Loc. cit.

[6] It would be interesting to determine whether the effect is dependent upon the axial direction of exposure. In the present case the needle-crystals were parallel to the electrodes.

Fish Hatching Systems

By A. Robertson

SPEAKING of fish hatchery work in general and the Pacific Coast Salmon hatcheries in particular there is no doubt that the present system of uncubation produces more fry from a given number of eggs than if the fish were allowed to deposit them naturally; but it is also well known to observers that hatchery fry are not equal in stamina to those hatched in the streams. The protection of the fry is recognized by all as the weak part of the system and considerable thought, labor and money is being expended to correct it, principally by retaining the fry to the fingerling stage.

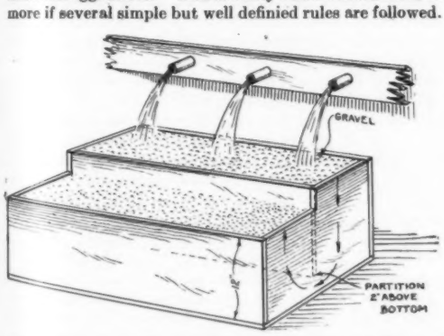
If the hatchery system and natural spawning have good points not common to one another, why cannot we combine them to offset on one hand the destructiveness of natural spawning and on the other the production of weak fry.

Analyzing the process of natural spawning we find that it can be summed up in few words, *i. e.*, that nature is prodigal and only the fittest survive. At the same time the survivors are very fit in comparison to our hatchery bred product. Turning to the hatchery system we find that it excels in all particulars where nature falls down. These are, more thorough fertilization, and protection from freshets washing out or burying the eggs, receding water leaving them dry, and the depredation of fish, fowl and animals.

Until recently the growth of fungus in the gravel due to the decomposing of infertile eggs was considered very destructive but observation has shown that this is not so unless movement of the gravel takes place which in itself is sufficient to destroy.

The discovery that the infertile egg, the source of most of the trouble in hatcheries, has a life of its own goes a long way to simplify the combination of the two systems.

This life may be described as a state of existence without growth and independent entirely from that of the embryo, but sufficient to keep the infertile egg from decomposing and thus polluting the adjoining good eggs, until the eggs hatch. This life may last for six months or more if several simple but well definied rules are followed.



These are: 1. The eggs, when taken carefully and fertilized in the ordinary dry method of stripping, must be placed in their permanent abode before they harden.

2. They must be held immovable and not disturbed in any way until the good ones hatch.

3. A constant stream of preferably spring water must be circulated directly among them.

4. All light should be excluded.

This can be accomplished in the ordinary white fish hatching jar, in which the writer first observed the phenomena, which allows a clear view of what is transpiring, where the water is conducted to the bottom through a tube and allowed to rise in the jar.

Though the white fish jar is correct in principle when kept in the dark, a much cheaper and just as efficient container can be built out of ordinary lumber as depicted in the accompanying sketch.

If the principle of direct water circulation is rigidly adhered to the form of the container is immaterial, but after experimenting with eight different forms the writer found the one depicted the best when economy was considered.

This box is three feet long, one foot wide and 12 inches and 15 inches deep. Made out of one inch lumber and treated with asphaltum. The method of operation is quite evident, the water being conducted into the high side passes down and under the partition and up and out of the lower side.

The writer used ten gallons per minute in this box but less may be sufficient.

In the white fish jar the water is used only on the rise, in the container depicted it is used in both directions and if finer gravel is used at the intake it acts as a filter, stopping at the surface matter likely to block the gravel.

The narrow form of the box insures good water circulation and prevents dead spaces in the interior, though it must be admitted that it is not as easy to fill as some others used.

The use of gravel as a medium in which to bury the eggs seems to be the best though it is quite reasonable to presume that other ways may be found to hold the eggs immovable while allowing for expansion and the passage of the water.

Using gravel from one inch to two inches in diameter (not water worn preferred), it will be found that the eggs assume the shape of the interstice in which they lodge without injury and not too close together to prevent swelling as the embryo grows. Some of them may become elongated twice the length of their breadth. The point to aim at is to fill all crevices without allowing the rock to rest on the eggs. If an interstice is only partially filled an eddy may set up killing the eggs by the movement.

In filling, a layer of rock or gravel is placed evenly in the bottom and the soft eggs are evenly and gently distributed by hand. Water is then sprinkled on the mass to settle the eggs into the interstices, and rock and eggs added alternately until the box is filled to the top on both sides. The eggs need not be actually in the water until the filling is completed, but the filling should be done as expeditiously as possible. To the uninitiated this may appear rough treatment of so fragile things as fish eggs, but they may rest assured that no harm will ensue if the eggs have not hardened. To attempt it with hardened eggs before they are well eyed is disastrous, but after the eggs are eyed they can be handled safely.

As stated previously the white fish jar is ideal to note the progress of development, the writer filled several jars to within three inches of the top with eggs without gravel, plugging the opening with moss to prevent movement. At the end of four months one jar had a perfect record, some others showed from two to six bad eggs and another in which the eggs were allowed to roll was 10 per cent bad. All the jars were allowed to hatch without the bad ones being picked out, and it was noted that a peculiar slime localized the effect of the decomposing eggs by providing food for the fungus to feed on.

The filling of the containers solidly with eggs was only done experimentally and the use of rock or gravel is advocated in all cases, as without it the fry are churned around by the water.

Fry hatched in the gravel instinctively burrow down until the sac is absorbed, and hatched in the dark they are light shy causing them to hide under stones, etc., when they do emerge. It may be taken as approximately correct that during the first few months of their lives, stream bred fry hide nine-tenths of the time and hatchery fry one-tenth, and that only when pursued.

The smooth even sides and bottm of a hatching trough are not conducive to fostering the hiding instinct of the little fish, and in addition the movements of the hatchery attendents soon accustoms them to movement; a fatal mistake. For this reason no attempt should be made to retain gravel hatched fry as it simply undoes that which we are striving for.

A good plan would be to place the hatchery boxes where they could be flooded to half their depth and as the fry emerged they could find access to the open with the waste water.

The Utilization of Pyrite Occurring in Illinois Bituminous Coal

THE mineral pyrite (or probably its true name is marcasite) occurs in nearly all Illinois coals as characteristic brassy yellow colored streaks, thin plates, lenses, nodules, bands, or balls of all sizes, sometimes up to 10 or 12 inches in thickness. In the ordinary course of mining pyrite is rejected as a deleterious impurity. Its presence in the coal in any considerable quantity not only affects the appearance and consequently the salability of the fuel, but when burned, pyrite promotes the formation of clinkers. Its heating value is small, and the sulphur dioxide gas formed from its combustion, in combination with water vapor, forms an acid which tends to corrode boiler flues and stacks.

Pyrite when pure contains more than 50 per cent of sulphur and when the nearly pure mineral is properly burned or roasted, the sulphur dioxide gas resulting forms the basis for the manufacture of sulphuric acid. In normal times the commercial supply of sulphuric acid is obtained as a by-product of the roasting and refining of zinc, lead, or copper ores which contain sulphur. The prohibition against undue atmosphere pollution in the neighborhood of zinc lead, or copper smelters due to the formation of sulphur dioxide and its discharge into the atmosphere, has often made its recovery a matter of necessity not regulated entirely by market demands for the resulting sulphuric acid.

In normal times in the United States the market for pyrite has been irregular and has been limited to small areas near the points of production and utilization owing to the fact that high freight rates have operated against extensive distribution. Moreover Spanish pyrite has normally been imported easily and cheaply to the extent of a million tons or more per year, usually in vessels which would otherwise return to America in ballast. In normal times also considerable crude sulphur has been available for the manufacture of sulphuric acid. All of these factors have affected the general market to such an extent that the commercial demand for pyrite which might be recovered during the mining and preparation of Illinois coal has been uncertain. Moreover, since the pyrite must be freed of adhering coal and refuse before shipment, the extra cost of this process has been an added disadvantage in the normal close competitive market.

In 1915, according to the report of the United States Geological Survey, 964,634 long tons of pyrite were imported while the domestic production was only 394,124 long tons, or about 29 per cent of the consumption. Of the domestic pyrite, 14,849 long tons are credited to Illinois, all of which, except a small amount from the northwestern part of the state, came as a by-product of the coal industry. Of this, possibly 12,000 tons came from one plant in the Danville district. In general then, little attention has been paid to the recovery of pyrite by the coal producers of the state.

Since the beginning of the European war new conditions have arisen. The supply of Spanish pyrite has been largely cut off, and under present market conditions (July, 1917) a clean pyrite product is worth from three to four times as much per ton as the coal with which it occurs. Sulphuric acid is used extensively in the manufacture of explosives as well as in the preparation of fertilizers, and the great increase in the demand for these products coupled with the reduction of the supply has advanced the price to a point which seems to present new possibilities in connection with the recovery of pyrite from Illinois coals. Some coals contain so large an amount of pyrite that its utilization under present conditions seems commercially practicable, and at certain mines the refuse piles contain large quantities accumulated from the picking belt at the tipple, from hand picking in the railroad cars, or from the coal washeries. It even seems probable that high sulphur coals could be crushed and washed to advantage, but with a view of saving the contained pyrite rather than of obtaining a cleaner coal. Although at present there is an almost unlimited demand for pyrite, it should be remembered that market conditions may change and, with the amount of pyrite available at most mines, large and expensive plants are probably not warranted. It becomes necessary, therefore, to design and to install small plants which will free most of the pyrite from the coal adhering to it and will otherwise treat it to make it acceptable as a commercial product. Through the kindness of W. G. Hartshorne of Danville, the Mining Engineering Department of the University of Illinois has been able to secure several lots, each of about one ton, of crude hand-picked pyrite mixed with its adhering coal. Experimental work in the laboratories has been conducted with a view of obtaining pyrite clean enough for the market and also coal as a by-product, clean enough to pass as ordinary tipple screenings. The experiments were performed as regular class ore-dressing experiments by senior students in the department of Mining Engineering under the direction of the writer, and approved compilations from these results have been used to supply part of the data to be outlined. The possible commercial use at the present time of these results by the mining industry was suggested by F. W. DeWolf, Director of the Illinois State Geological Survey.

Attention is called to the fact that the process outlined in this circular has not been developed with the ordinary small laboratory or hand apparatus. The mining laboratory of the University of Illinois is equipped with machines which are of commercial character and which differ from commercial machines only in being in most cases of half their dimensions. It is thought, therefore, that the results of these experiments are applicable directly to a commercial plant, and it is with the hope that the information acquired may prove beneficial to the coal mining and allied industries that it is published. —From Bulletin No. 51 of the Engineering Experiment Station of the University of Illinois.

Exterminating Tsetse Flies

A COMMUNICATION has reached us from Mr. Timmler, a civil servant in British conquered territory, German East Africa, New Langenburg, on the subject of the destruction of tsetse-flies. It is the somewhat surprising one of "gassing" the flies with a gas preferably innocuous to man, but fatal to the flies, or if deadly to man and flies, the use of masks, etc., would become imperative while operations were proceeding. The suggestion is that the monsoons would carry the gas across the fly-infested areas. We regard the proposal as impracticable, but an experiment would be better than any expression of adverse opinion.—From *Nature*.

Flint Fracture and Flint Implements*

Some Experiments Made With a View to Solve an Important Archaeoligical Problem

By J. Reid Moir

THE correct determination of human flaking upon a flint has always been a vexed question with archæologists. The difficulty arose apparently, in the first place, with the discovery of the Neolithic axes and arrow-heads, as the late Sir John Evans (*Ancient Stone Implements of Great Britain*, 2d edition, pp. 56 and 362) mentions that in certain old books these specimens are described respectively as "Thunder-bolts" and "Elf Arrows," clearly proving that a supernatural origin was accorded to them. Though we have no evidence that advanced archæologists were in existence in those somewhat remote times, yet it seems feasible to suppose that even then there were some unable to accept the supernatural theory and who claimed that the flint axes and arrow-heads represented the work of human brains and hands. Be that as it may, the fact remains that no one has for many long years disputed the human origin of these particular flaked flints, which are now universally accepted as affording conclusive evidence of human intention.

But the condition of quiescence so long prevailing in prehistoric circles was rudely shattered by the discoveries of Boucher de Perthes in the valley of the Somme. About the year 1841 it became noised abroad that definite flint implements of man had been found in undisturbed river-gravels of this district, associated with the bones of extinct animals, and that these discoveries afforded evidence of the existence of man at the remote period when these animals existed, and prior to the time when the ancient gravels containing their remains were laid down. Immediately these discoveries were made known to the scientific world, archæologists were plunged into a most violent and bitter controversy regarding the flaked flints discovered. The majority of authorities made haste to repudiate the claim of Boucher de Perthes, and asserted that the flints had been flaked by natural causes, and if not, then they had been made by the workmen at the pits, who had surreptitiously inserted them in the gravel from whence they were removed by the enthusiastic but misled archæologist. The various and extraordinary arguments put forward against the human origin of the palæolithic implements discovered by Boucher de Perthes are fortunately preserved and can be studied in a book entitled *The Antiquity of Man*, consisting of papers selected chiefly from the *Transactions of The Victoria Institute* (Elliot Stock, 62, Paternoster Row, London, E.C.).

There were, however, a few men who, having seen and handled some of Boucher de Perthes' specimens, stated they were in agreement with his opinion as to their human origin.

But these opinions made little headway, and for many years the majority of archæologists held to the belief that the flints found in the valley of the Somme had been flaked by some unknown natural forces.

Gradually, however, opinion began to change. Investigations carried out in river-gravels in this country and elsewhere established the fact of the occurrence in these deposits of similar flaked flints to those found by Boucher de Perthes, and at length, after much searching of heart on the part of the archæological world, palæolithic man came into his own. With the general acceptance of the palæoliths, a condition of comparative tranquility once more descended upon the question of man's antiquity; and though there were some bold spirits who held that an elaborately flaked palæolithic implement could not, in the nature of things, represent man's first effort in the fashioning of flint, and that in consequence his earlier efforts would probably be found in deposits more ancient than the palæolithic river-gravels, yet these were but "voices crying in the wilderness," and little heed was paid to them. The mutterings of the coming storm, which was to sweep away the orthodox limits set to the antiquity of the human race, were first heard from Ightham in Kent, where Mr. Benjamin Harrison, having found palæolithic implements in the oldest river-gravels of his district, began to investigate still more ancient deposits situated on the high plateau of Kent. These investigations resulted in the discovery of a series of rough flints exhibiting flaking along one or other of their edges. This discovery and the announcement that several archæologists, including the late Sir Joseph Prestwich, regarded these specimens as affording evidence of the former existence of a race of beings much more ancient than the makers of the palæoliths, initiated another period of unrest, and for the third time the archæological world was grievously disturbed, and the usual division of forces took place.

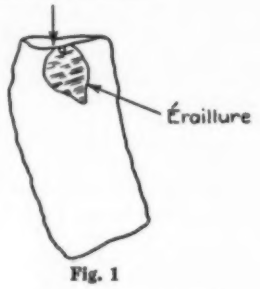


Fig. 1

Those who supported Mr. Harrison asserted that the flaked flints he had discovered were undoubtedly the work of man, and represented the type of implement which they would expect to find in such an ancient deposit; while his opponents contended that the flaking on the flints was undoubtedly due to natural pressure or percussion and therefore not indicative of human handiwork. Since the publication of Mr. Harrison's discoveries, a number of pre-palæolithic implements which seem to link up the primitive Kentian implements with the later palæoliths have been found in various Pliocene and early Pleistocene deposits in East Anglia, and these specimens, though accepted by an ever-widening circle of prehistorians, have in their turn been regarded by certain investigators as representing the work of nature. It will thus be seen that the science of prehistory has advanced only by slow and somewhat painful steps, and it may be of interest to inquire into the causes of this tardy progress.

Fig. 2

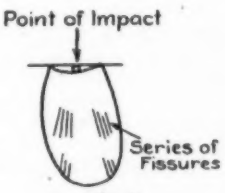


Fig. 3

The prolonged and heated controversies which have inevitably followed any new discoveries of flaked flints tending to extend the antiquity of the human race indicate clearly that the acceptance or non-acceptance of these specimens has not been actuated by any clear and definite scientific knowledge of the differences exhibited by flints flaked by man or by the unguided forces of nature.

If such knowledge had existed the controversies which have raged round the neoliths and palæoliths, and which are now being conducted in regard to the pre-palæoliths, would either have not occurred at all or, if commenced, would have been of a less prolonged and heated character. But in the absence of definite scientific data, other and less satisfactory means for arriving at a decision had to be employed. A prehistorian expressed himself to be in favor of accepting or not accepting any given flaked flints, simply by reason of his preconceived views and personal prejudices, and the majority of investigators are still swayed by such unscientific influences. In the long run what is known as "common sense" prevailed in regard to the neoliths and palæoliths, and there seems but little doubt that the pre-palæoliths will also be finally accepted on the same grounds; but the processes of common sense are slow and not necessarily scientifically adequate, and other and more satisfactory means of determining whether a flint has been flaked by man or by nature ought to be available. It appears that the only method likely to lead to definite and satisfactory results would be to conduct a series of experiments in which flints would be subjected to the effects of fortuitous percussion, and pressure, and to critically compare the fractures so produced with others caused by a hammer-stone held in the hand, and used in the manner in which ancient man probably used it. It might be urged that it is impossible to simulate experimentally the effect of natural forces upon flints, but on the other hand it seems reasonable to suppose that fortuitous blows and pressure do not differ fundamentally, whether brought into action by nature or in experiments conducted by a human being. The "mightiness" of natural forces cannot certainly be imitated experimentally, but it has been ascertained that flints will only stand, without disintegration, a certain amount (by no means very large and easily equalled in experiments) of pressure and force blows, and that in consequence when the natural forces in operation are too mighty, the flint must be shattered and reduced to fragments. The author concludes, therefore, that the experiments he has conducted in the flaking of flint are of value in this discussion, and though further researches may be necessary before the problems connected with human and natural flaking are finally and completely solved, yet he feels that the results already obtained may help to dispel some of the doubts and difficulties, and thus place the question of the antiquity of man upon a firmer and more scientific foundation. It is proposed in the first place to tabulate and describe some of the details of flint fracture, to which reference will be made in the description of the experiments carried out. The nature of the experiments in which flints were subjected to fortuitous percussion, and the conclusion arising therefrom, will then be described, and finally in a like manner the experiments in which fortuitous pressure was employed[1]

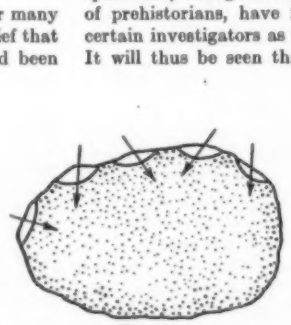


Fig. 4

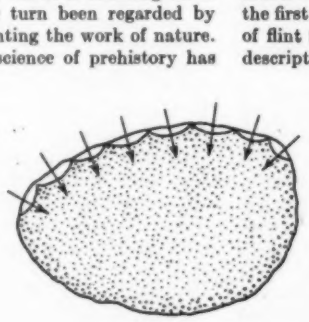


Fig. 5

DETAILS OF FLINT FRACTURE

Striking Platforms.—When an ordinary nodule of flint is selected with a view to produce an implement from it by flaking, it is necessary, owing to the difficulty of removing flakes from a rounded surface, to break off a portion of the nodule, so that a flat surface is produced, upon which blows removing flakes can be struck with precision. The flakes which are removed will exhibit, in the immediate vicinity of the point where the blows fell which detached them (known as "the point of impact"), a portion of this flat surface, and this is termed the "Striking Platform."

The Cone of Percussion.—When a certain type of blow is delivered in the center of a flat surface of sound flint, and the portions of this surface surrounding the point of impact tapped gently with a hammer, these portions will generally fall away, revealing a more or less perfect cone of flint. This is known as "the cone of percussion," and is due to an inherent

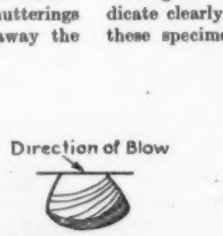


Fig. 6

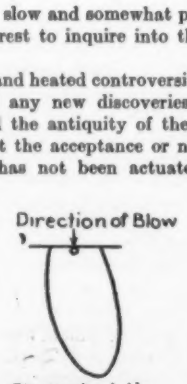


Fig. 7

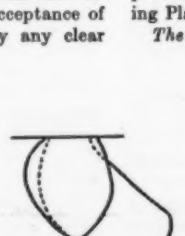


Fig. 8

*From *Science Progress.*

[1] A complete series of the flints fractured experimentally can be seen and examined in the Department of Ethnography at the British Museum (Bloomsbury).

property in the flint itself to fracture in this manner. This peculiar method of fracture is also found to be present in some other substances, such as glass, obsidian, etc.

Positive and Negative Cones of Percussion.—When a flake exhibits just below the point of impact a conical protuberance, and the block from which it was struck a corresponding hollow or depression, the former is known as the "positive," and the latter as the "negative" cone of percussion. The detached flake may as often exhibit the negative cone and the parent block the positive, but that does not affect the validity of the description given above.

Éraillures.—If a number of flakes removed by blows are examined it will be seen that many of them exhibit on their bulbar surfaces (that is, the surfaces upon which the positive cone of percussion is visible) a scar, where a small and isolated flake has become detached. This small flake is apparently removed simultaneously with the detachment of the larger flake, but the exact reason for its removal does not appear up to the present to have been satisfactorily explained. This éraillure or "mark" is sometimes seen upon flakes removed by pressure (Fig. 1).

Ripple Marks or Conchoidal Ripplings.—These ripple marks, which are often seen upon flakes and implements of human manufacture, and also upon flints flaked by fortuitous means (they appear to be more prominent and frequent upon the latter), are due to the tendency of flint under certain conditions to fracture in a conchoidal or shell-like manner. It seems that these conchoidal ripplings are somewhat analogous to the ripples produced upon a surface of water when some heavy object is thrown on to it. The water is "jarred" by the impact and ripples produced, and it may be that certain blows jar the flint and so produce ripplings on the fractured surface. Conchoidal ripplings are sometimes formed when a flint is fractured by pressure.

Fissures.—If a series of flakes is examined it will be noticed that their surfaces exhibit a series of fissures of varying length and width, which radiate from the point of impact. Some of these markings are easily visible to the naked eye, while others require a strong lens to discern them. It seems that their presence can be accounted for by supposing that when the flake is removed the flint is in a sense torn and that these markings represent the tears produced by the cleaving effect of the blow. Fissures are sometimes produced upon a flint which has been fractured by pressure.

Truncated Flakes.—When the manufacture of a flint implement is commenced, large flakes are removed from the nodule of flint, which in the further process of flaking get reduced in size or truncated. Thus, it is possible to observe the remains of flakes which have been thus reduced in size on various portions of the surfaces of many implements. These flakes are termed "truncated flakes."

Opposing Cones of Percussion.—Under certain conditions a flake removed by pressure may exhibit a well-marked cone of percussion at each end. This is due to the flint having been squeezed between two hard objects, and the cones represent the points at which, respectively, pressure and resistance acted. These cones are known as "opposing cones of percussion."

Experiments with Flints subjected to Fortuitous Percussion.—Seven or eight flint nodules of various shapes and sizes were placed in a sack and violently shaken about for some little time, and in such a manner that the flints were in almost continual collision. It was found that only the stones of a certain shape—and conforming more or less to a wedge in form (the thin edge of the wedge being usually attacked)—were flaked in this process The rounded flints in the sack were not flaked, but escaped with contusion of their surfaces only. A careful examination of the flaking produced by these fortuitous means, and a comparison of it with that due to human blows, appears to show that there is a fundamental difference between the two methods of fracture. This difference is, primarily, the angles at which the flakes have been removed. The method adopted to ascertain the direction in which any given flake has been removed from a flint is as follows: A line is drawn down the center of the flake and at right-angles to the ripple-marks (these in many cases require locating with a good lens). Then two other lines are drawn one on each side of the central line, and also at right-angles to the ripple-marks as they curve upwards. The three lines are then continued to their point of junction, which point indicates the area upon which fell the blow that detached the flake (Fig. 2).[2]

The correctness of this method can be checked by observing the direction of the small fissures or "splits," which gives an additional indication of the angle at which the flake was removed (Fig. 3). Careful outline drawings were then made of the flints flaked in the sack experiment, and also of those shaped by human blows.

Each flake area was accurately drawn and the direction of the blows responsible for the flaking indicated by arrows.

When this was done it was seen that the flints from the sack had had their flakes removed at divergent angles to the edge of the stone (Fig. 4), while those fractured by human blows had had them removed at a constant angle (Fig. 5). It does not appear possible that fortuitous haphazard blows would remove flakes at a constant angle to the edge of any flint, neither does it seem reasonable to suppose that any human flaker would go to the trouble of making a sharp edge by means of divergent blows, as the result would be much less satisfactory than one produced by the normal method. It appears then that we have here a good and simple means of distinguishing between the work of man and of nature.[3]

A further examination of the specimens fractured in the sack experiment demonstrated that the flakes which

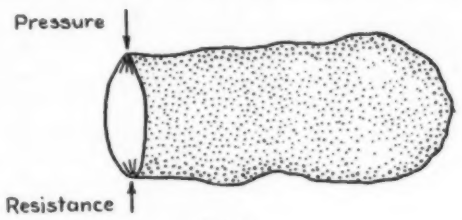


Fig. 9

had been removed differed in appearance from those due to human blows, this difference being—

(*a*) The "squatness" of the fortuitous flakes as compared with those removed by human agency (Fig. 6).

(*b*) The fact that the former had cut deeper into the flint, causing a step or ledge to appear at the point of their final separation from the parent block Fig. 6); and

(*c*) The occurrence of numerous prominent ripple-marks upon nearly all of the flakes produced by fortuitous blows, as compared with their comparative scarcity upon the "human" flakes (Fig. 6).

The explanation of these differences may be explained as follows:

In intentional human-flaking, a flat striking platform is produced, and blows are delivered on one or the other side of this platform, and in such a manner that the flakes removed are generally the reverse of squat, being of greater length than width, and thinnest at the point of their final separation from the parent block (Fig. 7). Such flakes are also generally free from prominent ripple-marks, due, in the author's opinion, to the fact

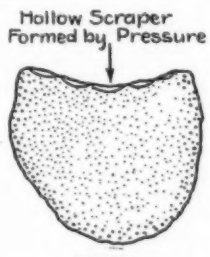


Fig. 10

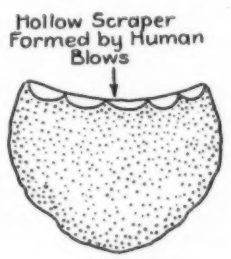


Fig. 11

that the blows which detached them were delivered almost vertically to the striking platform. In flaking produced by fortuitous percussion the great majority of the blows fall, not upon the side of the edge of the flint, but almost directly upon the edge itself, and it is known that blows so delivered remove flakes squat in form and productive of a step or ledge at the point of their final separation from the parent block.

It has been ascertained that consistently to remove flakes exhibiting prominent ripple-marks upon their surfaces, it is necessary to strike the flint an oblique blow. As has already been mentioned, a blow delivered vertically to a flint surface will remove a flake almost devoid of ripple-marks, and it is supposed that such a blow has less jarring effect upon the flint, and consequently produces less rippling of the fractured surface, than one delivered in an oblique direction. The explanation of the frequent occurrence of prominent ripple-marks upon fortuitous flakes, and their comparative scarcity upon those produced by human blows may be as follows. It may be assumed that there are 180 angles at which a flake may be removed from any given length of edge, but it is only more or less vertical blows, delivered at a few of the higher angles, that will remove flakes exhibiting insignificant ripple-marks. Thus in fortuitous haphazard blows the chances are that the greater number of blows will be delivered at the lower angles, which are oblique to the edge of the flint, and which, as has been shown, remove flakes exhibiting prominent ripple-marks upon their surfaces. It seems, then, that in the shape of the flakes, their character at the point of final separation from the parent block, and the presence or absence of prominent ripple-marks upon their surfaces, afford further criteria for determining whether any particular series of flints has been flaked by man or by nature.[4]

It was noticed that the edges of all the wedge-shaped stones fractured in the sack experiment showed a tendency to assume a sinuous outline due to blows having fallen upon either side of these edges.

The majority of the stones exhibited this sinuosity in an incomplete manner, but one specimen showed a markedly sinuous edge 4½ inches in length. A critical examination (based upon the tests already described in this paper) of the flaking to be seen upon this flint demonstrated clearly its "natural" origin, but another characteristic of the flaking was detected which seems to still further differentiate it from the work of man. It was found that the edge of this flint, though only 4½ inches in length, exhibited 17 truncated flakes (Fig. 8).

On the other hand an examination of various neolithic and palæolithic implements with sinuous edges demonstrated that the average number of truncated flakes on an edge seven inches long is only six.

The explanation of the greater number of truncated flakes upon an edge produced by fortuitous blows as compared with one formed by human agency may be that in the former case the rain of blows is almost continuous and the flint is continually being reflaked and truncated flakes formed. It is, however, somewhat difficult to imagine any human flaker being so inept at his work as to be compelled to form 17 truncated flakes in the production of an edge 4½ inches in length.

The author considers therefore that the proportion of truncated flakes upon a flint may furnish a further criterion for the determination of human as against natural flaking.[5] Various other experiments in fortuitous percussion, such as the hurling of a flint upon others lying on the ground, were carried out, and the results found to be similar to those obtained in the sack experiment.

Experiments with Flints Subjected to the Effects of Fortuitous Pressure.—Experiments were conducted with an adapted letterpress, and a differential screw press, with which considerable pressure was obtained.

It was found that when a suitably shaped stone was placed upon the floor of the press, and another smaller stone placed on the top of it and near its edge, a flake could be removed from the lowermost flint by forcing the ram of the press down upon the uppermost. Such flakes exhibited "opposing cones of percussion" (Fig. 9), due to the pressure upon the upper portion of the flint being equalled by the resistance afforded by the floor of the press. The presence of a cone of percussion at each end of these flakes differentiates them from those detached by human blows, on which only one bulb of percussion is visible. When a duster was placed upon the floor of the press so that the flint rested upon a soft basis, it was found that a flake could be removed, but only with the exertion of considerably more pressure than was needed in the former case. It was noticed also that such flakes exhibited only one cone of percussion, at the point where the small upper stone impinged upon the flint, as in the case of flakes removed by human blows. The majority of these cones of percussion, however, are flat and appear to be only partly developed, and in this respect they differ from the majority of cones of percussion produced by human blows. Pressure flakes, too, seldom exhibit well-marked éraillures, while the fissures and ripple-marks, if present, are of a different order from those present upon humanly-struck flints.

These differences are readily observable when a representative series of each kind of flake is put out for examination, and appear to be due to the different nature of the two fracturing forces. The human flaker is able to guide the line of fracture, within limits, in any direction he pleases, while in the case of pressure and flint is squeezed until it can stand the strain no longer,

[2] This method is adopted only when dealing with a truncated flake; when the actual bulbar cavity is present such a method is not needed.

[3] The author has examined and made flaking diagrams of a large number of flints found upon sea-beaches, and the flakes removed from these specimens by fortuitous battering are at markedly divergent angles.

[4] In arriving at a decision it is necessary to examine not less than twenty or thirty specimens; a lesser quantity examined might lead to erroneous conclusions.

[5] In the re-sharpening of many neolithic scrapers and Moustier (palæolithic) racloirs a number of small truncated flakes were produced, but these are not of the same order, or comparable to the truncated flakes described above.

and finally fractures along the line of least resistance. Future investigations may perhaps modify this explanation, but at present the author regards it as affording a likely reason for the difference, which undoubtedly exists, between flakes removed by pressure and those detached by human blows. Experiments were also conducted in which a hard resistant stone was placed upon the floor of the press, and another with a sharp edge placed against it in such a manner that the descending ram would cause this sharp edge to move under pressure over the surface of the other specimen. By this means a flaked hollow was produced in the sharp edge of the uppermost stone.[4] Several of these hollows were produced and compared with others formed by human blows. This comparison demonstrated that there was a marked difference in the appearance of the two series of hollows.

It appears that when the sharp-edged flint is being moved under pressure over the surface of the underlying stone very thin flakes or scalings are removed. This is due apparently to the fact that the pressure is able only to attack a very narrow area of the edge of the moving stone, and in consequence only very thin flakes are removed.

In flaking produced by human blows, it is impossible to strike so near to the edge of the flint as to remove flakes as thin as those detached by pressure, and a hollow flaked by the former means always appears, and is, more uneven and less finished than one produced by pressure.

The pressure hollows appear "smoother" than those of the other kind, because, the flakes being thinner, the ridges intervening between them are less prominent (Fig. 10).

In the case of the human blows, which cut more deeply into the flint, and remove thicker flakes, these ridges are correspondingly more marked (Fig. 11)[5]

The foregoing experiments in fortuitous percussion and pressure have been repeated many times and the results found to be uniform in each case.[6] It is to be hoped that prehistorians will be able in future to give more attention to the question of the natural and artificial fracture of flint as affording the only means of arriving at satisfactory conclusions regarding the "humanity" or otherwise of the specimens which are the subject of their study. Mere speculations as to the capabilities of man or nature to flake flints in the remote past are, in the author's opinion, of little value.

[4] A similar result can be obtained by placing a sharp-edged flint upon another stone lying on the ground and turning one's heel round on them, under pressure.

[5] The author has lately examined the Eocene flint-bed resting upon the chalk at Bramford, near Ipswich, where many specimens have been fractured by natural pressure in the bed in which they now lie. This examination has shown that the fracture Eocene flints reproduce in a marked degree the characteristics of those fractured by pressure in the experiments described. See *Proc. Prehis. Soc. of E. Anglia*, vol. 1. Part IV. pp. 397-404.

[6] Further experiments are in progress, and if the results obtained throw any further light upon the problems discussed in this paper, these will in due course be published.

An Attempt to Separate the Isotopic Forms of Lead by Fractional Crystallization*

By Theodore W. Richards and Norris F. Hall

ALTHOUGH the complete inseparability of isotopes by chemical means has been frequently asserted, the evidence on which this assertion is based has always seemed insufficient. The methods used have been fractional crystallization and precipitation, but these processes have seldom been carried out more than ten times in a particular case, and frequently six or seven crystallizations have been thought a sufficiently thorough test of inseparability. A search of the literature revealed only one investigation that of Radiothorium and Thorium by McCoy and Ross (*Journ. Am. Chem. Soc.*, 1907, xxix, 1709), where as many as 100 repetitions of a given process had been made. Thorium nitrate was dissolved in nitric acid and reprecipitated 100 times with excess of ammonia, but without change in the relative concentration of the isotopes. Precipitation with hydrogen peroxide (40 times) was also without result.

It seemed worth while, therefore, to apply to the important generalization of Fajans, Russell, Fleck, and Soddy, a more searching test, carrying the fractionation further, and using as a criterion of success not only the measurement of radioactivity but also the determination of atomic weight.

The lead from Australian carnotite, with which the kindness of Mr. S. Radcliff and Mr. E. R. Bubb had supplied us, and which had been used in previous atomic weight and density determinations in the Wolcott Gibbs Memorial Laboratory (Richards and Wadsworth, *Journ. Am. Chem. Soc.*, 1916, xxxviii., 1659), seemed well suited to our purpose, since its low atomic weight indicated a composition of three or four parts of the isotype (usually assumed to be radium G) to one of lead; and its β-ray activity showed that it contained sufficient radium D to serve as a basis for ionization tests of the possible separation of this isotope from the inactive varieties. The excellent work on radium D and lead by Paneth and von Hevesy (*Sitz. d. k. Akad. Wiss. Wien*, 1913, 122, IIa, 993) had shown, indeed, that no one of the many and diverse chemical methods applied by them had effected any separation of these substances, but even here no single operation had been repeated often enough to detect the effect of exceedingly small differences in chemical or physical properties.

PRELIMINARY PREPARATIONS OF MATERIAL

About one kilogrm. of the radioactive lead was taken for this work. This included much of the purified samples A, B, and C of the atomic weight work already referred to, some of which had not been used, and some of which had been recovered from the completed analyses. The samples of metallic lead which had been used in spectrographic tests and density determinations were also added, as well as all the mother-liquors remaining from the preparation of the purified samples. Much of this material was already in the form of nitrate, some in the form of chloride, and some was metallic. The chlorides were converted into nitrates by repeated evaporation with pure nitric acid, and the metal was dissolved in the same acid. All the nitrates were then combined, dissolved in the least possible quantity of boiling water, and precipitated by the addition of large quantities of pure concentrated nitric acid and cooling in an ice bath. The crystals were separated from the mother-liquor with a porcelain funnel, washed with concentrated nitric acid, and the washings and mother-liquor united. The strongly acid mother-liquors were evaporated to fuming with sulphuric acid, and the sulphates almost completely precipitated by dilution. The sulphates were converted to carbonates by boiling with sodium carbonate, washed nearly free from sodium, and dissolved in nitric acid. The small amount of nitrates thus obtained was evaporated to dryness and added to the bulk of the nitrates. No attempt was made to purify further at this stage, because the unavoidable introduction of much silica during the fractionation (as well as possible accidental contamination) made necessary the thorough purification to which the samples were subjected just before the final tests.

* From the *Chemical News*.

FRACTIONAL CRYSTALLIZATION

The method of crystallizing the nitrate by cooling the boiling nearly saturated aqueous solution was adopted after preliminary experiments on the chlorate and perchlorate of lead had indicated the superiority of the nitrate to these more soluble salts for the work in hand.

This superiority consists in the well-known habit of the nitrate of forming compact, large prisms on crystallization from water solution, which can be very completely freed from mother-liquor merely by drainage, as well as in its slight tendency to supersaturation, and the consequent rapidity with which crystal-liquid equilibrium is attained.

The whole of the nitrate was then dissolved in distilled water and evaporated until a crust began to form This was called Fraction 1. After cooling to room temperature the mother-liquor was poured off and formed Fraction 2. To the crystals from Fraction 1 was added sufficient water to dissolve them, and the solution was called Fraction 3.

Fractions 2 and 3 were evaporated to saturation and cooled as Fraction 1 had been, the liquor from 2 forming Fraction 4. Fraction 5 was made by adding the liquor from 3 to the crystals from 2, and water was added to the crystals from 2 to form Fraction 6. This process was continued as shown in the diagram until, as occurred first with Fraction 16, one of the end fractions became too small to work with conveniently, and was consequently added entire to the mother-liquor from Fraction 17 to form Fraction 22. This expedient was resorted to wherever the end fractions became inconveniently small. In all, 75 courses or tiers of fractions were obtained, most of the last of which contained 18 fractions to a tier. The number of the last fraction was 1006.

The crystallization was carried out entirely in porcelain, at first in large evaporating dishes, then, as the fractions became smaller, in casseroles covered with watch glasses. The hot casseroles were usually set in evaporating dishes full of cold water, which was frequently changed to hasten cooling. The fractionation was stopped after about 1000 repetitions because, since an accuracy of 2 per cent was hoped for in the final tests, 1,000 fractionations would show whether a difference in solubility amounting to one part in 50,000 for a single crystallization existed or not. In other words, if the end fractions tested at this point showed no difference in the relative concentrations of their components, within the expected error of measurement of 2 per cent we should have proof that no complete separation could be attained by this method in less than *fifty thousand fractionations*.

Through the courtesy of Prof. Gregory P. Baxter, the facilities of the T. Jefferson Coolidge Memorial Laboratory were extended to one of us during the summer of 1916, when this part of the work was carried out. Thanks are due to Prof. Baxter, not only for this kindness, but also for many helpful suggestions which his experience with rare-earth separations made doubly valuable.

Repeatedly the advantage of centrifugal separation of mother-liquor from crystals has been demonstrated in cases of ordinary crystallization where the crystals and mother-liquor are very different in composition. It is possible to show, mathematically, however, that where there is no such great difference the advantages of centrifugal draining is very much less, and in the present case it was found by this calculation that the gain in effectiveness of separation was less than the disadvantage caused by the increased time necessary for the centrifugal treatment of the thousand precipitates. Making the reasonable assumption that the difference in solubility in this case is probably not greater than 2×10^{-5} the relative advantage of centrifugal over gravitational drainage is seen to be certainly not greater than 1.5: 1, so that it would be hopeless to try to increase the rapidity of separation by this means. Even under the best conditions with multiple-basket power centrifugals which could be stopped almost instantly, the time required would certainly be more than half again as much as for mere gravitational drainage. Therefore, in the present case, centrifugal draining was not adopted. Baxter, in his crystallisations of praseodymium and neodymium compounds, had come to the same conclusion from practical experience. A note discussing this matter mathematically will soon be published by one of us.

PURIFICATION

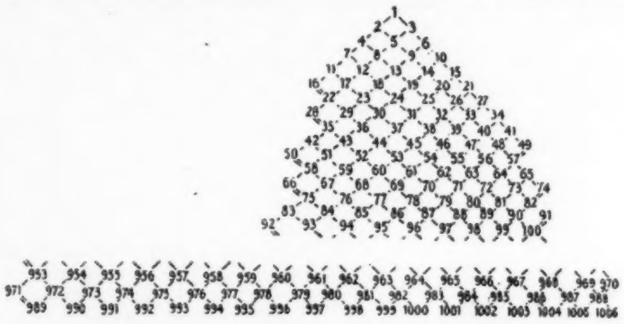
Because of the smallness of the end fractions it was necessary to unite several to obtain a sufficient quantity of material for purification.

(NOTE.—This action nullified the effect of 19 crystallizations on the more soluble end and 83 crystallizations on the less soluble end. Thus the total number of effective crystallizations was 904. The mother-liquor on the less soluble end resulted from an average of 71 tiers of successive products, and on the more soluble end from an average of 65 tiers. It is to be regretted that this reduction in the efficiency of the process was rendered necessary by the small yields at the two ends of the line, but enough crystallizations remained effective to test the question at issue, at least in a preliminary way).

From the mother-liquor, or "more soluble" end Fractions 989-992 were taken, united and called Sample A. Sample B was made up of Fractions 999-1006 from the crystal, or "less soluble" end. From this point on the two samples were treated in an identical manner. Chiefly to remove the large amount of silica which had dissolved from the casseroles during the fractionation, the crystals were first electrolyzed in warm concentrated solution between platinum wires. The well-formed flat leaflets of lead were removed from time to time with a glass rod, rinsed with a stream from a wash-bottle, and preserved in quartz dishes until all the metal had been deposited from the solution. The crystals were further washed from time to time, and all washings returned to the electrolysis bath, which was gradually reduced in volume as the concentration of lead became smaller. The lead crystals were then dissolved in a nitric acid

made by diluting with the purest three times distilled water, nitric acid which had itself been distilled through a platinum condenser with rejection of the first third. The excess of acid was evaporated, and the crystals of lead nitrate dissolved in the purest water, filtered through a platinum Gooch crucible, and precipiated by the addition of a large excess of redistilled nitric acid, and cooling with ice. The crystal meal thus obtained was freed from adhering acid in the platinum centrifuge, washed centrifugally with purest concentrated acid, and redissolved in the least possible amount of pure boiling water.

Five precipitations with centrifugal drying were made in this way. The crystals from the fifth crystalization were placed in a quartz dish and dissolved. From this solution lead chloride was precipitated by passing in pure hydrochloric acid gas made by warming the purest acid of commerce. The chloride thus obtained was dried in the centrifuge, washed with cold water, and redissolved in boiling water. Four crystalizations as chloride followed. A little hydrochloric acid was added to the solution each time to prevent the formation of basic salt and to render the chloride less soluble. The last crystals, after centrifugal washing and drying, were preserved in an exhausted desiccator over fused potash. Nothing but platinum and quartz vessels were used.



The upper part of the diagram depicts the arrangement of the first 100 crystallizations. It contained 16 tiers of fractions. Fifty-six tiers of fractions, including 853 crystallizations, are omitted from lack of space. The last three tiers are given at the bottom of the diagram

Scheme of fractional crystallizations

THE DETERMINATION OF ATOMIC WEIGHT

For these determinations the usual procedure was employed. About five grams of the dried crystals were placed in a platinum boat, which with its container had been carefully weighed. The boat was gradually heated in a quartz tube attached to the usual "bottling apparatus," in a current of pure dry hydrochloric acid gas. After nearly all the residual water had been driven from the crystals the temperature was raised so as to fuse the salt, which was then cooled as quickly as possible in a current of pure dry nitrogen prepared by the Wanklyn process.

Mayer (*Phys. Review*, 1915, VI, 288), has shown that against an excess of pressure (such as was always maintained within our tube) no oxygen diffuses through a layer of quartz even as thin as 0.5 mm., and our tube walls were 2.5 mm. thick. (Incidentally it may be noted that Mayer's interesting results seem to indicate that when diffusion takes place it is rather of the nature of transpiration through actual holes than solid solution—for in the latter case small difference of pressure would make far less difference than he observed). This observation is confirmed by our experience. The hydrochloric acid delivered from the end of the tube dissolves in water without visible residue (indicating the absence of more than a trace of any slightly soluble gaseous impurity), and very rarely was there any significant corrosion of the boat, which would have occurred with only a trace of oxygen. Only once when the salt was kept fused a long time its brownish color on cooling showed that a little platinum had dissolved. This sample was, of course, rejected. The delicacy of this color test is shown by the weights of the boat before and after this fusion which differed only by 0.24 mgrm., although the salt was distinctly brown. No trace of color was observed in any other case, nor was the loss of weight of the boat otherwise over 0.09 mgrm.

After the salt had cooled and the nitrogen had been replaced by dry air the boat was pushed into the weighing tube, bottled, and reweighed.

The boat and salt were next heated at 80–90° on an electric stove in a glass flask containing about a liter of water to which enough pure nitric acid had been added to prevent the formation of basic salt, until the lead chloride had all dissolved. One sample boiled for a few minutes, and was rejejected at once for fear that a trace of the salt had been carried out by spray. As susual (Richards and Wadsworth, *Journ. Am. Chem. Soc.*, 1916, xxxviii., 2616), a small amount of siliceous and carbonaceous residue had to be removed by scrupulously quantitative filtration through a tared Gooch-Monroe crucible. On the average, about twice as much was found in the more soluble fraction as in the other. The weight thus removed was subtracted from the weight of the fused salt. Before filtration the boat had been carefully lifted out and thoroughly washed, and the filtrate was collected in the precipitating flask.

A supposedly equivalent weight of silver was next dissolved in pure nitric acid mixed with an equal bulk of water in a flask with a chain of bulbs ground into the neck, a steam-bath being used to heat the solution. More water was then added, and the temperature raised until a few seconds' gentle boiling had removed nitrous fumes. The solution having been made up to a litre it was added very slowly with constant agitation to the lead chloride solution. Actinic light was henceforth rigorously excluded from the precipitated silver chloride. The precipitate was coagulated by violent shaking, usually for fifteen minutes, and allowed to stand at least twenty-four hours, with further occasional shakings before samples were removed for tests. The end-point was found by the customary method by means of the nephelometer, and tested for several days to be certain that it did not change.

Vacuum corrections were applied as usual, and all customary precautions were taken.

Previous to this work two analyses of ordinary lead had been made. (The fused chloride made from this lead contained no perceptible trace of insoluble residue).

TABLE I.

Analysis.	Sample.	$PbCl_2$ corr. to vacuum.	Ag corr. to vacuum.	Ratio $PbCl_2$: Ag.	At. wt. Pb.
The Atomic Weight of Ordinary Lead.					
1.	Pb	7·13723	5·53723	1·28895	207·187
2.	Pb	7·60063	5·89675	1·28895	207·186
			Average		207·187
Atomic Weight of End Fractions of Isotopic Lead.					
7.	A	3·70016	2·87854	1·28543	206·426
9.	A	4·79633	3·73154	1·28535	206·409
14.	A	4·64577	3·61412	1·28545	206·431
			Average		206·422
10.	B	4·64736	3·61568	1·28534	206·406
11.	B	4·87838	3·79519	1·28541	206·422
15.	B	4·68396	3·64425	1·28530	206·399
			Average		206·409

Ag = 107·880. Cl = 35·459

Table I includes all the analyses of the materials which were completed; any which had become the object of suspicion were rejected at an early stage.

Obviously, if the fractional crystallizations produced any change in the relative concentrations of radium G and lead this change is very small. The means of the two series of determinations of isotopic lead differ only by about 6 parts in 100,000. This is certainly within the bounds of possible experimental error, though the low "average errors" of the two sets (0.008 unit in each case) tempt one to assign a meaning to the observed difference. At any rate, we are safe in concluding that assuming the atomic weights of radium G and lead to be 206.0 and 207.2 respectively, no change in concentration greater than 13/1200 or 1.1 per cent has been obtained by 900 crystallizations. Even supposing that a real difference in solubility exists, and making the further conservative assumption that the bunching of the end fractions reduced the effect of the crystallization by one-fifth it is evident that complete separation could not be attained in less than 70,000 fractionations. It is interesting to note again that the average amount of residue in the "more soluble" Fraction B, which must have contained a far larger original siliceous impurity, was 2.3 times as large as that in the "less soluble" Fraction A, and B is also the one which shows the lower atomic weight. This is confirmatory of the experience of Richards and Wadsworth (*loc. cit.*), who say: "It is noticeable that in general those preparations which contained appreciable amounts of the residue were slightly lower than the others as regards the final atomic weight obtained." Perhaps a trace of basic salt is carried away with the residue, thus causing its actual weight to be too great, and because the actual weight is subtracted from the total lead chloride, the apparent atomic weight of lead would consequently be too low. In that case the slight difference between Series A and B might be attributed to experimental error from this cause. The matter will receive further attention; in any case it does not seriously affect the conclusion.

ESTIMATION OF RADIO-ACTIVITY

The β-ray activity of the lead used indicates that it contains, in about 3 parts so-called "radium G" and 1 part lead, an amount of "radium D" of the order of 10-7 parts. This is betrayed by the steady growth of a penetrating β-ray product ("RaE") which comes to practical equilibrium with its parent in about a month after they are separated. Evidently the ionization, if the α-rays from the polonium present are cut off, caused by a weighed amount of the material under constant conditions, is a measure of the concentration of radium D relative to its isotopes "radium G" and lead. Thus the determination of the activity of the end fractions gives information as to the relation between the solubility of the nitrate of radium D and the mean solubility of the nitrates of radium G and ordinary lead, a relation of great interest because it cannot be tested by atomic weight determinations, and because the difference between the theoretical atomic weight of radium D and that found for the mixture is 210-206.4 = 3.6, or three times as large as that between radium G and lead. Any difference in the properties of isotopes might naturally be expected to be greater the greater the difference between the atomic weights; hence this case should afford an especially favorable test of the theory of complete identity.

The method was as follows: To eliminate differences in moisture-content, and consequently in absorptive power, the two samples were kept in the same exhausted desiccator after purification. When sixty-six days had elapsed 10.25±0.03 grms. of each sample were weighed into a marked metal dish and tamped with a platinum spatula. The material formed a layer of thickness defined by the expression 0.88 grm./cm^2. This is far too thin to give a maximum ionization due to the complete absorption of the β-rays from the lowest layers, but is thick enough so that no great accidental changes in thickness needed to be feared, and the effect of small changes was annulled as described below. The dishes were covered in turn with the same thin sheet of paper and introduced into a grounded aluminium-leaf electroscope which was very kindly loaned by Prof. William Duane. The rate of fall of the leaf was then observed with a stop-watch in the usual manner. The position of maximum sensitiveness was ascertained by preliminary experiments, and the telescope adjusted to this position. The leaf was then always charged to such a potential that it was at the same division of the scale at the beginning of each measurement. The time taken for it to reach another division on the scale (always the same one) was then noted. By this means all errors arising from differences of potential, differences of stiffness of the leaf in different positions, and in homogeneity of the scale were at once eliminated. The leaf was charged first to an indefinite potential higher than that desired, then by means of an active preparation of polonium held near the base of the electroscope, it was quickly discharged to a point a few scale divisions above the initial mark, and its slow passage across this mark was then observed at leisure. The two dishes were introduced alternately into the electroscope to eliminate the effect of changes in the natural leak, and were thoroughly stirred and repacked between every two measurements to allow for small accidental differences in thickness. The dish not in use was removed always to the same position at a distance from the electroscope and heavily screened so that no variation in the amount of radiation from this source could affect the rate of fall. The electroscope was carefully screened from all other radio-active material and from neighboring sources of X-rays. Illumination was secured from a tungsten filament lamp at a considerable distance from the leaf, and any convection currents caused in the gas inside the electroscope-case by radiation from this source must certainly have reached a steady state before the work was begun.

These somewhat elaborate precautions are discussed in detail, because it was not until many preliminary experiments had shown the necessity of observing them that a satisfactory degree of reproducibility was ob-

tained. Thanks are due to Drs. David L. Webster and Harry Clark for much kindly suggestion and assistance.

It is believed that Table II, which includes all the observations affected by no known source of error, represents about as good reproducibility as this electroscope can be made to give. The chief difficulty is in focussing so sharply on the edge of the leaf that the precise instant of its passage of any scale division can be exactly estimated.

TABLE II.

	Sample A.	Sample B.
	11·30	11·32
	11·43	11·62
	11·69	12·06
	11·56	11·43
	11·61	11·70
	11·47	11·34
	11·49	11·32
	11·50	11·43
	11·41	11·47
	11·58	11·36
Averages ..	11·504	11·505

The ionization is expressed in arbitrary units (scale divisions per minute). The natural leak (which must have been the same for both as they were taken alternately) was found to be 0.50±0.01. The agreement of the means to 1 part in 10,000 must be regarded as fortuitous, since their mean probable error is about 0.11 unit. This error, divided by the mean value from which has been subtracted the natural leak, is a measure of the accuracy of the determination. Its value is $\frac{11}{1150-50} = \frac{1^{\circ}}{100}$

This work definitely shows, then, that no change in the relative concentration of radium D and its isotopes as great as 1 per cent has occurred in 900 fractionations, and certainly gives no indications that even a smaller change has occurred. In other words, making the same conservative assumption as before, we have proof here that *radium D* cannot be completely separated from its isotopes by this method in less than 80,000 *crystallizations*.

If ordinary lead is a mixture of isotopes this mixture must have been made very long ago while the earth was still in a highly mobile condition, since all the ordinary lead throughout the world seems to have the same atomic weight (Baxter and Grover, *Journ. Am. Chem. Soc.*,, 1915, xxxvii, 1058). Could the composite nature of ordinary lead be proved the identity of the several samples through geological aerons would form another argument infavor of the inseparability of the constituents.

To the Carnegie Institution of Washington we are greatly indebted for some of the apparatus and material used in this research, which is to be continued in the near future.

SUMMARY

Lead from Australian carnoite (believed to contain about 1 part of ordinary lead to 3 parts of radium G, with a mere trace of radium B) has been fractionally crystalized over one thousand times as nitrate, and the end-fractions purified.

The atomic weights of the samples so obtained from the crystal and the mother-liquor ends of the series, respectively, agreed within the experimental error of 6 parts in 100,000.

The β-ray activities agreed within the experimental error of 1 per cent.

These observations indicate that the nitrates of radium D and lead, on the one hand, and radium B and lead, on the other hand, could hardly be separated, if at all, by less than 100,000 crystallisations.

Hence one might infer that the molal solubilities of the nitrates are probably essentially identical. The outcome gives strong experimental support for the hypothesis that isotopes are really inseparable by any such process as crystallization.

Color and Reactivity

By C. Scott Garrett

A SERIES of papers on materials for experimental dispersoidology has recently been published by Weimarn in the *Journal of the Russian Physical Chemistry Society*, which in the light of recent theories of constitution and reactivity are of some considerable importance. Most chemists who have followed the developments which have resulted from the application of spectroscopic methods to the phenomenon of color—using the word in its broadest sense—in chemical substances will be familiar with the theory recently advanced by Baly on the subject. Baly's theory, in part at least, associates the delicate changes of color experienced by many organic substances when the nature or concentration of the solvent or some other variant is slightly altered, with a process of opening up of the solute, in the sense that the chemical forces within the molecule as a whole are no longer so strong as originally in some particular horizon, which horizon depends on the nature of the variant impressed. The change is not one which affects what we might call the stereotyped configuration of the molecule or system, but is one in which a reactivity of some definite character, hitherto more or less latent, is developed. On these lines it is possible reasonably to explain many facts in organic reactivity which have been long looked upon as empyrical results. While Baly's theory has been developed mainly in connection with organic chemistry, it is nevertheless equally applicable to inorganic chemistry. Inorganic chemistry, however, presents fewer examples of the type met with in organic chemistry, possibly because the opened-up phases have such temporary existence, or possibly because these phases are evidenced by absorption spectrum changes in an inaccessible region. The recent observations of Goldstein on the production of color in solid salts containing infinitesimal impurities by bombardment with cathode rays, are susceptible of explanation on the lines of this theory, and the same is the case with the observations of Weimarn on colored solutions of sulphur to which we have referred. Weimarn finds that sulphur dissolves with an indigo or blue coloration in water, ethyl, propyl, isobutyl, and amyl alcohols, acetone, glycerol, and ethylene glycol if these solvents are rendered alkaline. In a few cases the trace of alaklinity derived from the glass of the containing vessel is sufficient to induce the blue color. In neutral or acid solutions, however, no coloration is developed—the explanation of which, on the lines of the above theory, is that the sulphur molecule complex possesses an acidic nature, and is consequently opened up and made reactive by basic or basified solvents. When the solvents possess a neutral character *per se*, or are acidified, the tendency will be for the sulphur molecule to remain unaffected or become closed, and consequently color will be absent. Further, Weimarn has noted that any solution of a polysulphide becomes blue on heating, provided the solvent is not acid in character, and does not exert a definite "coarse" chemical action on the polysulphide.

Again, by suitable arrangment of these two variants, temperature and concentration, it is possible to obtain colors comprising the whole range of the visible spectrum. This characteristic blue color is probably the same as is obtained in fusions of sulphur and salts, such as potassium chloride, and solutions of sulphur in ammonia or sulphur trioxide.

Undoubtedly the sulphur molecule is a very reactive one, and since its various reactive states are evidenced by light absorption in visible and accessible regions, a study of the absorption characteristics of organic and inorganic sulphur compounds ought to prove well worthy of intensive investigation.

Weimarn's observations are confirmatory of some observations already published. By their recently developed method of preparation of pure alkaline polysulphides from alkaline hydrogen sulphides, Rule and Thomas have shown that in the pure solid state these compounds possess a clear gradation of color, whilst in solution almost any color can be produced by suitable variations of solvent, concentration, and temperature.

Maleducation and Malpronunciation

ONE would think that, after our excellent schoolmasters have been teaching us Latin and Greek for some centuries, we should by now possess some elementary knowledge of what these languages probably sounded like when they were spoken. Of ourse as the ancients published no works on phonetics, we cannot be sure of their pronunciation; but we may at least infer with a very high degree of probability that Latin and ancient Greek sounded more like modern Italian and modern Greek than like Cockney English. For example, the vowels have much the same sounds in all the romance languages but quite different sounds in modern English. Reforms are now certainly being made, but we still hear *dominus* pronounced with an English *u* at the end and *amo, amas, amat* given an appalling pronunciation. Yet our public schools and universities even award high marks for writing verse in these languages. What are we to think of the following doggerel which makes *patria* rhyme with *away*?

Qui procul hinc, the legend's writ—
The frontier-grave is far away—
Qui ante diem perlit:
Sed miles, sed pro patria.

Shelley, who certainly ought to have known better, makes *Uranis* rhyme with *lay*, and our diphthongs are impossible. We once heard a Greek play at a university, but our pleasure in it was spoilt by the shouts of laughter indulged in by some Greeks who were sitting behind us. The Greek of Oxford-atte-Bowe appears to belong to that exclusive university; for when a modern Greek reads a bit of Homer one can really quite appreciate the rhythm! But if this matter is mentioned to a classical scholar he shudders with horror and demonstrates (what the modern Greeks deny) that the old accentuation was entirely wrong. However, we had better not plunge any further into this thorny wood.

It is time also to make a strong protest against the pronunciation of English blank verse on the stage. Evidently in the age of Marlowe and Shakespeare, the rhythm was given its full force, with the swing intended by the authors; but our actors love to jumble all the words just as people do in ordinary conversation round a tea-table—so that one does not know whether the character is intended to be talking verse or not. It reminds us of the clown's remark after a pathetic piece of music, "Say, are you singing a song or lodging a complaint." Probably poor Poetry is as dead as mutton in the England of to-day, and for the same reason that poor Science lives in the kitchen like Cinderella—while their prosperous sisters, Maleducation and Impolitics, go to all the balls and enjoy a place in the sun.—*Science Progress.*

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